

become more scientific. This will aid in its important mission of seeking truth. It should become less dogmatic about the origin of the universe and matter/energy, of life and evolution. It also should be less dogmatic about the ability of the human race to cure all diseases, make the blind see and the deaf hear, raise the dead and make truly intelligent machines with feelings and emotions. And finally it must not deny social science the variable of human freedom.

References

- Chapman, R. D. 1978. *Discovering astronomy*. W. H. Freeman Company, San Francisco
- Coffey, P. 1958a. *Epistemology*, Volume II. Peter Smith, Gloucester, MA.
- Coffey, P. 1958b. *Epistemology*, Volume I. Peter Smith, Gloucester, MA.
- Coffey P. 1938. *The science of logic*, Volume II. Peter Smith, Gloucester, MA.
- Coffey, P. 1970. *Ontology*. Peter Smith, Gloucester, MA.
- Crick, F. H. C. 1979. Thinking about the brain. *Scientific American* 241:219-32.
- Dreyfus, H. L. 1979. *What computers cant do*. Harper and Row, New York.
- Dubray, C. A. 1938. *Introductory philosophy*. Longmans, Green and Company, New York.
- Halverson, W. H. 1958. *A concise introduction to philosophy*. Random House, New York.
- Henle, R. J. 1985. Reflections on current reductionism. *The New Scholasticism* LIX:131-55
- Joad, C. E. M. 1946. *Guide to philosophy*. Dover. New York.
- Koren, H. J. 1955. *An introduction to the philosophy of animate nature*. B. Herder Book Company, St. Louis.
- Labarre, W. 1956. *The human animal*. The University of Chicago Press.
- Mountcastle, V. B. 1968. *Medical physiology*, Volume II. C. V. Mosby Company, St. Louis.
- Popper, K. R. 1968. *Conjectures and refutations: the growth of scientific knowledge*. Harper and Row, New York.
- Randall, Jr., J. H. and J. Buchler. 1971. *Philosophy: an introduction*. Harper and Row, New York.
- Schoeck, H. and J. W. Wiggins (Editors). 1966. *Scientism and values*. D. Van Nostrand. Princeton, NT.
- Taube, M. 1961. *Computers and common sense*. Columbia University Press, New York.
- Tax, S. (Editor) 1966. *Evolution after Darwin*, Volume I. (The evolution of life). The University of Chicago Press.
- Welzenbaum, J. 1976. *Computer power and human reason*. W. E. Freeman and Company, San Francisco.

INVITED PAPER

FIVE-LINKED FOOD CHAIN OF INSECTS*

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Abstract

Within southwestern Chicago the food relations of a five-linked food chain of insects (a case of hyperparasitism) was studied. The larvae of the large Saturniid moth *Hyalophora* (formerly *Samia*) *cecropia* (Linnaeus), while feeding upon black willow, box elder, and wild black cherry, served as the key industry for four successive links of hymenopterous parasites (more accurately named **parasitoids**). The primary parasite was the ichneumonid *Spilocryptus extrematis* (Cresson); the secondary parasite was *Aenoplex smithii* (Packard); and the tertiary and quaternary parasitic positions were held, respectively, by the chalcids *Dibrachys boucheanus* (Ratzeburg) and *Pleurotropis tarsalis* (Ashmead).

Contributing to the delicate dynamic balance of this food chain were the tachinid fly *Winthemia cecropia* (Riley) (formerly *W. datanae* Tns.), two additional ichneumonids *Ephialtes aequalus* (Provancher), and *Hemiteles tenellus* (Say) and the chalcids *Dimmockia incongruus* (Ashmead) and *Cirrospilus inimicus* (Gahan).

Reference is made to an assumed controversy throughout all the natural world between the Creator and Satan. A brief discussion is also included suggesting how, from a creationist viewpoint, a change in food in some animals from plant sources to animal sources, may have occurred.

Introduction

Within the Chicago area near Summit, Illinois, there is a level prairie community supporting scattered clumps of black willow, box elder, and wild cherry. These trees were found to be heavily infested with cocoons of *Hyalophora* (formerly *Samia*) *cecropia* (Linnaeus), the infestation being reasonably constant from year to year. The writer became engaged in a study of the feeding interrelationships existing between

these trees, the *Cecropia* larvae, and the involved chain of hymenopterous parasites and hyperparasites— see Marsh, 1934: pp. I-IV, 1-98). This opportunity is taken to discuss briefly certain general aspects of the problem, e.g. the biotic balance between moth, predators, and parasites.

Methods

In collecting the material for this study, the cocoons were kept in three separate groups: (a) those found on the ground— chiefly beneath brittle-stemmed willow trees, (b) those spun from the ground to a height of 15 ft., and (c) those spun from 15 to 35 ft.— the upper limit of cocoons in this region due to the absence of high trees. Age or condition of cocoon made no difference in the uniform sampling of the area. Thus the regulatory factors of several years were determined. The separation into groups according to the stratum occupied was made in order to learn the vertical spread of the factors involved.

*Throughout the course of this work I have had the advantage of counsel from Dr. C. L. Turner (Northwestern University). It is also a pleasure to acknowledge the criticism of Dr. Orlando Park (Northwestern University) and I am especially indebted to the following taxonomic experts, J. M. Aldrich, R. A. Cushman, A. B. Gahan, C. L. Metcalf, C. F. W. Muesebeck and C. W. Sabrosky for their care in determination of insect material.

**Much of the material in this article first appeared in *Ecology*— see Marsh (1937). Permission for its use here was given May 5, 1986, by the Ecological Society of America.

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The life-history details of the host and parasites were learned from much observation and collection in the field and from laboratory study. In the latter the ichneumonids and chalcids were reared in test tubes lightly stopped with cotton. Honey diluted with an equal part of water proved the most successful diet for the adults.

Ecological Observations

A quantitative analysis of the biological influences acting upon the *Cecropia* cocoons is illustrated in Table I. The table represents the results obtained from a dissection of 2741 specimens. The feeding interrelations discerned in this study are given in Figure 1. From these two groups of data certain interesting facts may be noted. Thus the ichneumonid *Spilocryptus extrematis* (Cresson) appears to be one of the most important influences in regulating the emergence of the moth, destroying 22.8 percent of all cocoons. Again, the birds (Hairy Woodpecker and Downy Woodpecker) were second with a destruction of 6.8 percent, the mice (Meadow Mouse and Whitefooted Mouse) were third with a destruction of 3.8 percent, and finally the tachinid was fourth, destroying 3.1 percent of the *Cecropia* cocoons.

In the Chicago area *Cecropia* begins to spin about the middle of July. From the time the first mature larva surrounds itself with as much as a thin shell of silk, up to the time when the last pupa case has hardened, about the end of August, the moth is open to attack by its chief enemy *S. extrematis*. The abundance of *Cecropia* in the area studied can be imagined from the finding of 19 cocoons in a single cluster on a young black willow tree, while as many as 253 old and new cocoons were found on single adult willows. See Figure 2. Still, a casual visitor in the region would not suspect their presence due to the rapid leaf replacement by the willow and box elder, and to the habit of the larvae while feeding, of scattering over the entire food plant. Table II lists the food plants of *Cecropia* in this region in graduated series from most stimulating to least

stimulating as judged from the abundance of cocoons found on these plants.

The Five-Linked Chain

In Figure 1 it will be noted that *S. extrematis* in turn served as the host of five parasites. However, attention will now be directed to the central chain leading through *S. extrematis* which, in this study, gives the best case of hyperparasitism, ending with the accidental quaternary parasite (Smith, 1916) *Pleurotropis tarsalis* (Ashmead). In this case *Cecropia* is the primary host. It is possible that *S. extrematis* is attracted to its host by the odor of freshly spun silk. As soon as cocoon spinning has progressed to a thin-shell stage, females of the ichneumonid have been observed coming up the wind to it as *Canthon* beetles follow up wind to fresh horse droppings. The ovipositor is thrust through the cocoon, and eggs are deposited on the inside of the cocoon or on the surface of the larva. Over 1000 eggs have been counted in one early-spun cocoon resulting from the oviposition of several females, while the greatest number of cocoons of *S. extrematis* in a single *Cecropia* cocoon was 172. As no starved larvae have been found, cannibalism is indicated. The average infestation of *Cecropia* cocoons with *S. extrematis* was found to be 33. During oviposition, the host larva is thrust with the ovipositor and invariably dies within a few hours. The larvae of *S. extrematis* move about freely over the dead host larva at first feeding on cuticle, later burrowing down and drinking the body fluids. In cases of heavy parasitism all the host body is eaten except the few chitinized parts. In the Chicago area *S. extrematis* is double brooded, completing a cycle in about 18 days.

Aenoplex smithii (Packard), the secondary ichneumonid parasite of this chain, appeared in about 13 percent of the *Cecropia* cocoons which were infected with *S. extrematis*. Because its host larvae are available throughout the year, the number of broods of *A. smithii* appearing in a season is governed by the duration of

Table I. A General Survey (calculated in percentage) of 2741 cecropia cocoons collected in the Chicago area in March. I. Cocoons found lying beneath the trees on the ground. II. Cocoons which had been spun from the ground up to a height of about 15 feet. III. Cocoons which had been spun in the trees at a height of about 15 to 35 feet.

Situation of cocoon	Pupa alive in cocoon	Adult emerged	Adult unable to push through valve	Adult dead in pupa case	Pupa destroyed by bird	Pupa destroyed by mouse	Pupa dead from unknown cause	Larve or pupa destroyed by ichneumon	Larva destroyed by tachina fly	Larva dead from unknown cause	Cocoon crushed	Scorched by grass fire	Number of cocoons in each group
I	14.3 ♂ ♀ 36 64	37.6 ♂ ♀ 53 47	0.2	0.8	1.9	14.9	4.1	13.6	1.3	2.2	8.7	0.4	516
II	35.5 54 46	17.2 49 51	0.5	0.3	2.6	6.0	2.1	25.8	4.3	4.8	0.9	None	1827
III	52.3 53 47	8.1 34 66	None	None	8.8	None	3.3	20.0	0.7	6.8	None	None	398
Average for all groups	33.6 52 48	19.7 49 51	0.3	0.3	6.8	3.8	2.5	22.8	3.1	4.4	2.6	0.1	2741

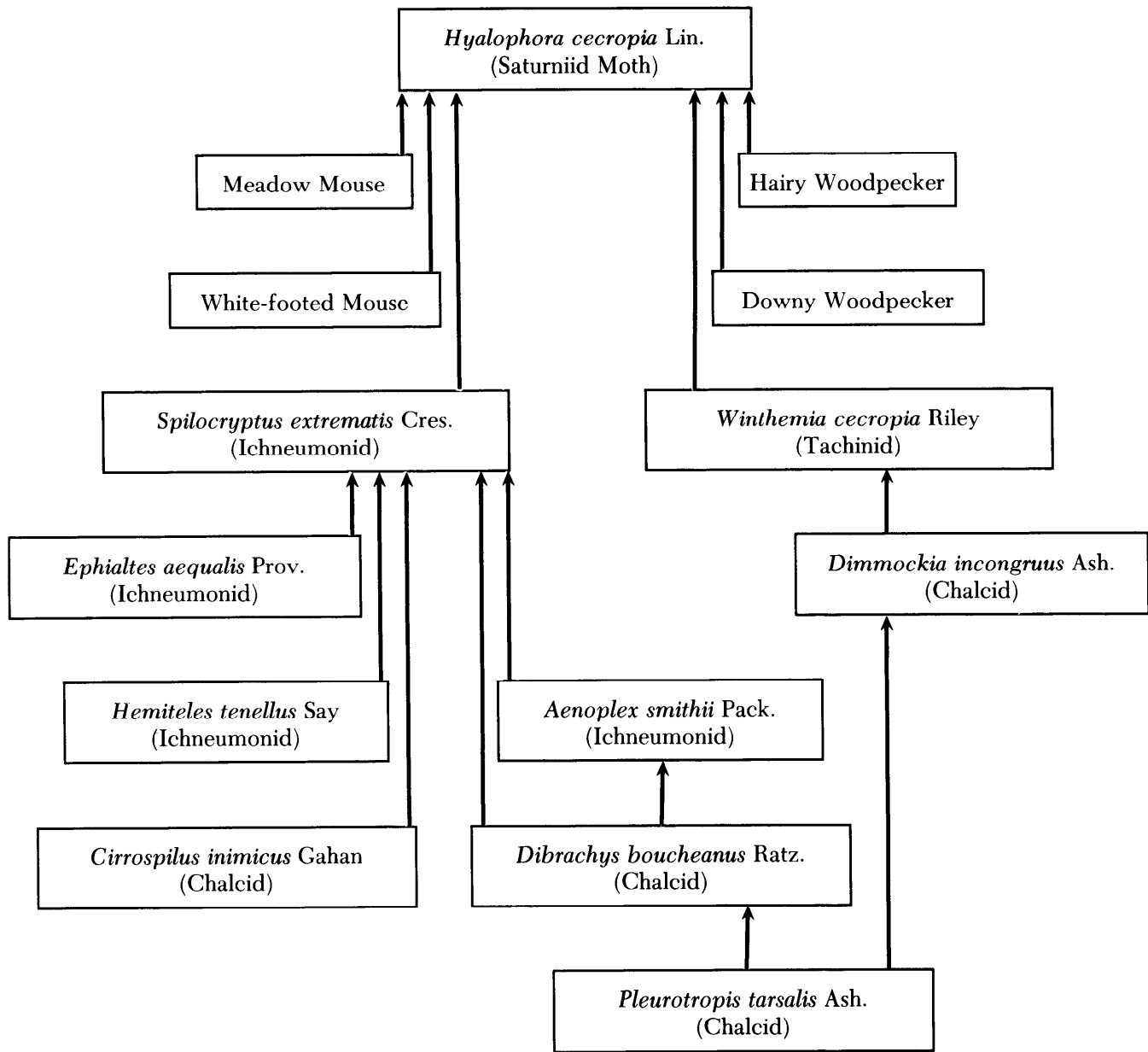


Figure 1. Diagram of the feeding interrelations discerned in the willow-Cecropia community.

the warm weather. Five successive groups of adults commonly appeared in a season in the area studied. The host larvae are located by careful palpation of the infected Cecropia cocoon with the antennae of the female. Due to the rather short ovipositor only those larvae cocooned in the periphery of the cavity inside the Cecropia cocoon can be reached. A single egg (rarely two) is laid inside the cocoon of each host larva. This larva is then thrust with the ovipositor and dies within a few hours. The larva of *A. smithii* is very active, moving about freely over the dead host drinking at numerous punctures made by its mandibles. As in the case of *S. extrematis* the cycle of *A. smithii* required about 18 days.

The omnivorous, cosmopolitan chalcid, *Dibrachys boucheanus* (Ratzeburg) appeared most frequently as a secondary parasite on *S. extrematis*, but because of the biological interest in its very frequent appearance as an accidental tertiary parasite of *A. smithii*, it is so listed here. Entrance to infected Cecropian cocoons is effected through holes previously made by woodpeckers, mice, or escaping ichneumonids, or if no holes are present, by crowding through the loose silk of the valve. Once inside, by palpation of the cocoons of *S. extrematis* with its antennae it determines the presence of a host larva and inserts its ovipositor, placing eggs on the surface of the larva. If a cocoon of *A. smithii* chances to be inside, its thin wall is also punctured and

Table II. Food plants in the Chicago area from which cecropia cocoons were collected, listed in the order of the number of cocoons found on each species of plant.

Scientific name	Common name
<i>Salix nigra</i>	Black Willow
<i>Acer negrundo</i>	Box Elder
<i>Acer saccharinum</i>	Silver or Soft Maple
<i>Prunus serotina</i>	Wild Black Cherry
<i>Populus balsamifera</i> var. <i>virginiana</i>	Cottonwood
<i>Syringa vulgaris</i>	Cultivated Lilac
<i>Maclura pomifera</i>	Osage Orange
<i>Rosa</i>	Cultivated Rose
<i>Arctium lappa</i>	Burdock
<i>Quercus macrocarpa</i>	Bur Oak
<i>Quercus alba</i>	White Oak
<i>Gleditsia tracanthos</i>	Honey Locust
<i>Ulmus americana</i>	American Elm
<i>Rhus toxicodendron</i>	Poison Ivy
<i>Calalpa speciosa</i>	Catalpa
<i>Polygonium hydropiper</i>	Smartweed
<i>Malus ioensis</i>	Wild Crab Apple
<i>Crataegus</i>	Hawthorne
<i>Aster ericoides</i>	Heath Aster
<i>Cannabis sativa</i>	Hemp
<i>Ambrosia artemisiaefolia</i>	Roman Wormwood
<i>Ribes floridum</i>	Wild Black Currant
<i>Ambrosia trifida</i>	Great Ragweed

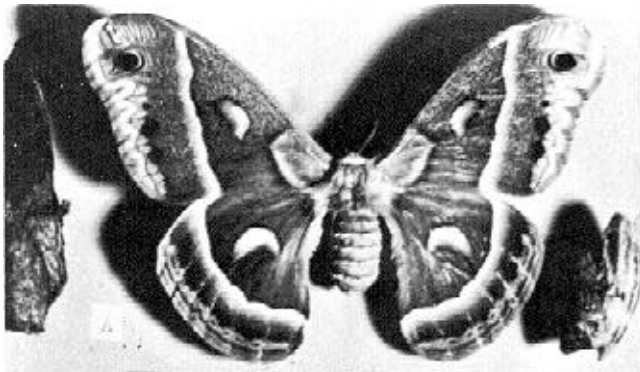


Figure 2. Satumiid, Giant Silkworm Moth. A. *Hyalophora cecropia* (Linnaeus). Female, wingspread 140 mm., cocoon at left, at right Cecropia pupa with cluster of *Spilocryptus extrematis* (Cresson) cocoons; B. Cecropia cocoons on black willow brush, baggy cocoons predominate near ground, tightly spun cocoons at higher levels.

eggs deposited. An average of seven eggs were placed on *A. smithii* and 12 on *S. extrematis*. As many as 53 pupae have been found on the remains of one larva of *S. extrematis*. *D. boucheanus* is a very effective controlling factor. Each female may lay from 300 to 400 eggs and six broods were found in the field in a season. In the laboratory the writer reared 19 generations of *D. boucheanus* in 12 months. Contrary to the report of Muesebeck and Dohanian (1927), the writer found that in the Chicago area *D. boucheanus* always hibernated as a straw-colored pupa.

The last place in this five-linked chain of insects was occupied by the small chalcid *Pleurotropis tarsalis* (Ashmead). According to the easy shifting of its host from the role of an obligatory secondary to that of an accidental tertiary, *P. tarsalis* naturally frequently occurred as either an obligatory tertiary or an accidental quaternary parasite. The larva of this chalcid is an internal feeder. The female, after gaining access to the Cecropia cocoon in the same manner as *D. boucheanus*, places a single egg (rarely two) just beneath the cuticle of the mature larva or freshly formed pupa. In this case the adult parasite does not kill the host, but this is accomplished later in the pupa case by the development of the parasite larva. From laboratory rearings and field observations in this area, *P. tarsalis* appears to complete at least three cycles during a summer. It invariably hibernates in the larval stage.

Associated Parasites

The two smaller secondary ichneumonid parasites *Ephialtes aequalus* (Provancher) and *Hemiteles tenellus* (Say) were with the chain but much less effective than *A. smithii* as parasites of the primary parasite *S. extrematis*. Their handicap in this relation was the shortness of their ovipositors (2 mm. as compared with 4 mm. in *A. smithii*). Where *A. smithii* could easily thrust its ovipositor through the tightly spun wall of Cecropia cocoons and reach those of *S. extrematis* inside, these two smaller ichneumonids could only occasionally accomplish the task. Their effect in this food chain is comparatively minor.

The only dipteran observed in this willow-Cecropia community of parasites was the tachinid fly which J. M. Aldrich of the National Museum at first identified as *Winthemia datanae* (Tns.). See Marsh (1937). Since that time the National Museum told me the insect more properly is not *W. datanae* but *W. cecropia*—which seems likely under the conditions. I will accept the latter species name. At their request the specimen shown in Figure 3 now rests in the National Museum, Washington, D.C.

This tachinid occurs in the Chicago area as a primary parasite, along with *S. extrematis*, of the key industry *Hyalophora cecropia*. Normally this tachinid fly emerges the second week in July, just as its Cecropia larval host has molted the last time before spinning its cocoon. This is important in the life of this tachinid because it lays its eggs on the larval surface and if placed earlier the eggs could be shed with the discarded skin. When considered over the whole area the parasitization of Cecropia by *W. cecropia* is rather light (3.1 percent, see Table I). Its distribution is in highly concentrated areas which frequently are quite widely scattered. In these spots (including several small

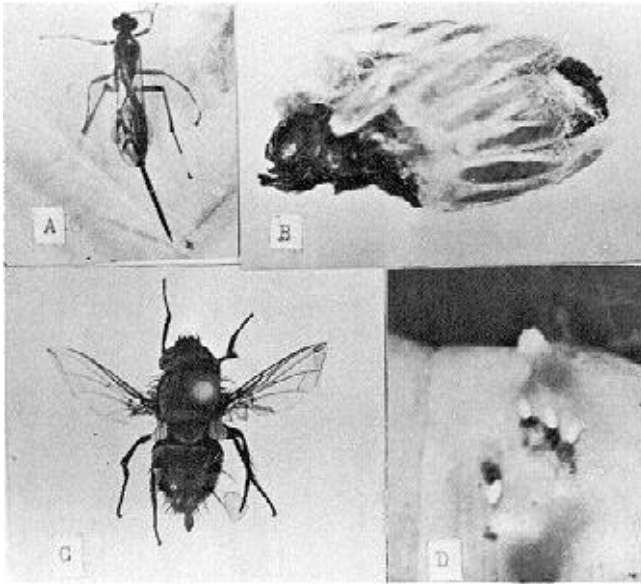


Figure 3. Ichneumon (A) and Tachinid (C). A. *Spilocryptus extrematis* (Cresson), female, body length (exclusive of ovipositor) 12 mm.; B. *Cecropia* larva surrounded by ring of *S. extrematis* cocoons, each about 15 mm. long; C. *Winthemia cecropia* (Riley), female body length 10 mm., this specimen is now in the National museum; D. Egg shells of *W. cecropia* on skin of *Cecropia* larva, dark streak from each shell is due to bacterial infection in the path made by the larva as it tunneled into the interior.

trees) the destruction of *Cecropia* is commonly total. During oviposition the female hovers over the larva's back, clinging to the larva's tubercles while the eggs are securely attached by their adhesive coating to the skin of the host along the dorsal line. An average of 21 eggs was found. In about 36 hrs. the larvae (maggots) hatch and gnaw their way directly to the celomic fluid of their host. The host usually completes its cocoon before dying. The parasites eventually devour everything about the host except its bloated and blackened skin.

The mature tough-skinned maggot of *W. cecropia* finds itself imprisoned in the *Cecropia* cocoon commonly 10 to 15 ft. above ground. The writer has photographs of the escape of the mature maggot through the cocoon valve, and of its burrowing into the ground after falling from the tree (Marsh, 1934). Pupation occurs in a small cavity constructed three to eight inches underground.

The only parasite of *W. cecropia* discovered in this study was the small chalcid *Dimmockia incongruus* (Ashmead). He often observed ichneumonid and chalcid parasites trying to pierce the cuticle of the maggots of *W. cecropia*, but to no avail because of its toughness. However he did once find two puparia of *W. cecropia* which contained 52 pupae of *D. incongruus*, 12 of which were in turn hyperparasitized by larvae of the tertiary chalcid *Pleurotropis tarsalis*. The tough surface of the maggot and also of the puparium of *W. cecropia* rendered it generally safe from danger of parasitization.

Off the main chain but still a very definite deterrent to the numbers of the primary parasite *S. extrematis* was a small, pretty, black-and-yellow chalcid wasp (body length: male 1.5 mm., female 2 mm.; see Figure 4D) which had a life cycle of from 18 to 21 days, and appeared to run at least three broods a summer. As

parasites their behavior was quite identical with *D. boucheanus*. In his identification of the writer's chalcids, A. B. Gahan thought this could be a new species of the genus *Cirrospilus*. A total of about 100 was sent to Gahan (the writer was raising them on his desk) which made the fact of a new species certain. So I invited him to assign the new name: This he did, calling it *C. inimicus* Gahan (1934). For some biology of this new chalcid species, see Marsh (1938). Those readers who desire more detail on the biology of the insects associated in this willow-*Cecropia* community are referred to the sources listed under Marsh in the References. An impressive point in the field study of this five-linked insect food chain is the fact that the fertile parasite arrives exactly at the most vulnerable period in its host's life cycle. This obviously involves perfect timing and points toward design rather than evolution.

This nicely balanced series along with other regulatory factors of *Cecropia* in the Chicago area seems to have produced an equilibrium in the abundance of the moth. The infestation of this moth is abnormally heavy, yet has apparently been of this degree for some time. See Figure 5. As expressed in the words of an interrogated "native" who had grown up in the area, the cocoons had "always been just that thick." A reasonable balance does appear to have been reached in the infestation by this moth so that, in recent years at least, *Cecropia* has neither increased nor decreased.

Discussion

True natural science consists of two parts, (1) demonstrable facts and (2) undemonstrable speculation about the facts. It is a *must* in true natural science that the scientist keep very clearly in view what is *demonstrable fact* and what is mere *speculation*. Up to this

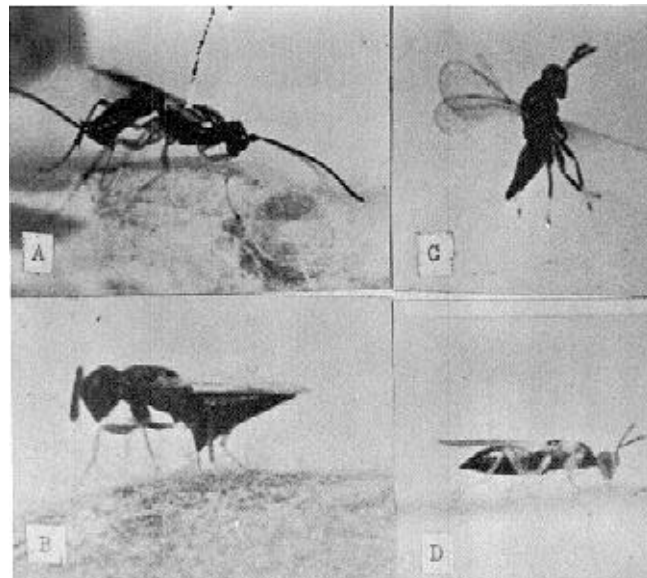


Figure 4. Ichneumonid (A) and Chalcids (B, C, D). A. *Aenoplex smithii* (Pachard), female, body length 8 mm., ovipositing in cocoons of *S. extrematis*; B. *Dibrachys boucheanus* (Ratzeburg), female, body length 4mm., ovipositing through thin cocoon of *A. smithii*; C. *Pleurotropis tarsalis* (Ashmead), quarternary parasite, body length 2.5 mm., parasitized *D. boucheanus*; D. New species of Chalcid genus *Cirrospilus*, *C. inimicus*, female, body length 3mm. discovered by Marsh and identified and named by A. B. Gahan, a parasite of *S. extrematis*, in photo drinking dilute-honey.

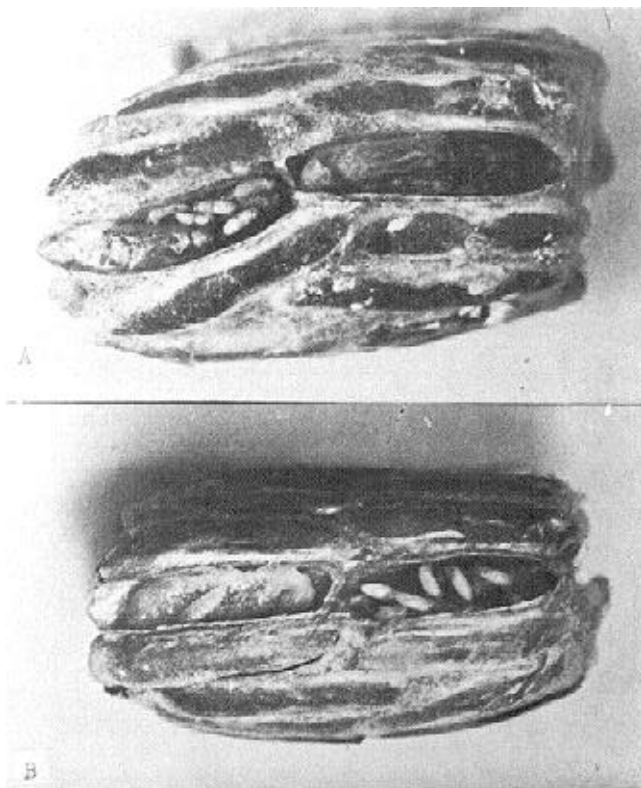


Figure 5. Hyperparasitism in clusters of cocoons of primary parasite *S. extrematis* taken from Cecropia cocoons. A. at left a cocoon of *A. smithii* and several pupae of *D. boucheanus* inside cocoon of *S. extrematis*, at right cocoon of *A. smithii* inside cocoon of *S. extrematis*; B. At left half-grown larvae of *A. smithii* feeding on larva of *S. extrematis*, at right larvae of *D. boucheanus* feeding on larva of host *S. extrematis*.

point in this article the author has reported demonstrable facts. These items should be the same whether reported by Bible-believer or atheist. Scientific facts are simply *facts* to all. The author of this article is a Bible-believer.

In my report I have called the parasitic wasps and a fly "parasites" in harmony with H. S. Smith's recommendations (1916, pp. 477-486). In 1966 R. L. Smith (p. 405) states that insects which attack their host *indirectly* by laying their eggs in or on the host, and later the eggs hatch and the larvae feed on the host until it dies, should be called *parasitoids*. Still more recently (1986) May and Seger (p. 260) continue to call parasitic wasps and flies *parasitoids*. Thus today when discussing predation I am careful as to distinguish between parasites and parasitoids. My present report concerns the latter.

From the writer's point of view (as a Bible-believer) he suggests that the only way to begin to comprehend our natural world is for the student to bear in mind that since a time soon following Creation Week, our world has been the battleground of a controversy between the great and loving Creator (Christ the Son) and the jealous and crafty destroyer Satan (Ezekiel 28). God's wisdom and fairness is shown in His permission to Satan to live and demonstrate his manner of directorship were he the King of the Universe. Briefly, all that is fair, loving, and beautiful comes from the Creator, and all that is evil, hateful, repulsive and selfish comes

from Satan. Both contesters in this controversy use natural laws as their implements.

Satan cannot create new life (Psalms 36:9). But I believe that he can degenerate living forms by gene manipulation. Scientists today know that Genesis kinds of organisms cannot hybridize. But they also know that crossbreeding between varieties *within* a single basic type usually is successful, but not uncommonly the hybrid will produce some poisonous substance or be abnormal some other way. Examples here are known among hybrids between varieties of monkshood (*Aconitum*) and guayule (*Parthenium*). In animals such hybrids often manifest changes in their original instincts. See Marsh (1981, p. 166).

In my opinion Satan has employed this manipulation of genes very widely in his worldwide degeneration of organisms. Let us speculate a little. We know from Genesis 1:30 that the original ancestors of the ichneumonid *Spilocryptus extrematis* were Herbivora (plant eaters) but in our study *S. extrematis* showed a preference for the fluids and tissues of cecropia larvae. Is it not possible that Satan has used his gene technique here to change an original instinct? If we are correct here then he has been quite busy because according to Ross (p. 449) in North America alone there are probably about 11,000 species of parasitic insects.

As in the case of Job, where the Creator set a limit to how far Satan could go in abusing Job, all through nature we can see where the Creator has checked some satanic activity. An example here may be the work of scientists in discovering the use of a Satan-produced poison to kill Devil-generated organisms.

This five-linked insect food chain is in delicate dynamic balance. It is interesting to study what would be the effect on the moth if any certain link were to increase or to decrease in number of individuals.*

References

- Gahan, A. B. 1934. A new species of *Cirrospilus* Westwood (Chalcidoide). *Proceedings of the Entomological Society of Washington*. 36 (5).
- Marsh, Frank L. 1934. A regional study of *Samia cecropia* and nine associated parasites and hyperparasites. An unpublished master's thesis (containing 127 photos) in the Northwestern University Library, Evanston, IL.
- _____. 1935. Cecropia-larva to pupa in pictures. *Nature Magazine* 25(6):312-3.
- _____. 1936. Egg placing by *Dibrachys boucheanus* Ratzeburg. *Canadian Entomologist* 10:215-6
- _____. 1937. Ecological observations upon the enemies of cecropia, with particular reference to its hymenopterous parasites. *Ecology* 18:106-12.
- _____. 1937. Biology of the tachinid *Winthemia datanae* (cecropia). *Psyche* XLIV(4):138-140.
- _____. 1937. Biology of the ichneumonid *Spilocryptus ertrematis* Cresson (Hymenoptera). *Annals of the Entomological Society of America* XXX(1):40-2.
- _____. 1938. Biology of the new chalcid parasite *Cirrospilus inimicus* Gahan. *Journal of the New York Entomological Society* XLVI:27-9.

* (Editor's note) Some creationists prefer to believe that the parasitic action of insects developed after the Fall. An alternate explanation would be imagining nature as a battleground (conservation vs. degeneration processes). See Williams, Emmett L. 1976 A Creation model for natural processes. *CRSQ* 13:34-7 or in 1981 Thermodynamics and the development of order, Creation Research Society Books, Norcross, GA 30092. pp. 114-19. If one prefers to view parasitism as part of the balance in nature, it can be visualized as occurring because of the interplay of conservation and degeneration processes. However parasitism originated, it is the result of design rather than accidental natural events.

- _____. 1981. Have the Genesis kinds ever crossed? *Creation Research Society Quarterly* 18:164-7.
- May, R. M. and Jon Seger. 1986. Ideas in ecology. *American Scientist* 74(3):260.
- Muesebeck, C. F. W. and S. M. Dohanian. 1927. A study of hyper-parasitism, with particular reference to the parasites of *Apanteles melanoscelus*. *United States Agriculture Bulletin* 1487; April.

- Ross, Herbert H. 1956. A textbook of entomology, second edition. John Wiley & Sons, New York: p. 449.
- Smith, H. S. 1916. An attempt to redefine the host relationship exhibited by entomophagus insects. *Journal of Economic Entomology* 9(5):477-86.
- Smith, Robert L. 1966. Ecology and field biology. Harper and Row, New York, pp. 33, 405-6.

CREATION RESEARCH SOCIETY STUDIES ON PRECAMBRIAN POLLEN— PART II: EXPERIMENTS ON ATMOSPHERIC POLLEN CONTAMINATION OF MICROSCOPE SLIDES

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Abstract

In criticizing studies of fossil pollen extracted from rock samples, positive results have been questioned or even discredited with the claim that various grains on the slides are merely the result of atmospheric, non-fossil pollen which contaminated the sample in the field or laboratory. Here we have undertaken to assess the rate at which pollen grains will actually contaminate exposed slides—with the goal of determining just how valid are the claims that pollen contamination might routinely occur in the laboratory or during field work.

Introduction

A. V. Chadwick (1981) attempted to repeat C. L. Burdick's discovery of pollen in Precambrian Hakatai shale samples from The Grand Canyon (1966 and 1972). Chadwick asserted that Burdick's apparent success probably had resulted from contamination:

The simplest hypothesis to explain Burdick's data is that the pollen grains he reported in 1966 and 1972 were modern contamination picked up either during collection and transportation or infiltrated into the sample itself prior to collection (Chadwick 1981, p. 9)

Here Chadwick did not directly attribute Burdick's pollen grains to actual contamination during laboratory processing, but he implied as much and he did assert that the samples probably got contaminated from the atmosphere/during collection or transportation.

In reporting on his own failure to recover pollen grains or spores from similar Precambrian rock samples (1981), Chadwick notes that he had used filtered air maintained at positive pressure in his palynological laboratory. Upon reading the Chadwick paper, one is left with the impression that air is normally loaded with spores and that unless the sample preparation room is supplied with filtered air under positive pressure, any slides examined are likely to show contaminant pollen from the atmosphere of the laboratory room itself.

In their letter to the editor of *Geotimes* (1973) Solomon and Morgan made the following comment concerning the claim that pollen grains in Burdick's 1966 paper were fossil pollen and not the same as those of modern pines or Douglas fir trees now growing along Grand Canyon walls:

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The point is important, for if the pine was modern, then Burdick's palynology instructor at that time was more likely correct when he initially identified the pollen as contaminating modern pine pollen (G. O. W. Kremp, personal comment). Coincidentally the pine populations some 1,000-4,000 ft. above Burdick's head were pollinating at the time he was collecting samples. (Solomon and Morgan, 1973, p. 10)

Thus by implication and direct statement these workers have also expressed the opinion that the pollen grains found in Hakatai Precambrian shale by Burdick had entered the sample from the atmosphere during the time the sample was being extracted from the strata.

While we believe that reasonable steps should be taken to avoid atmospheric contamination while gathering samples in the field and when processing them in the lab, we have wondered how much care is really necessary. We were curious regarding just what must be done to insure that spores seen in preparations from rock samples actually represent pollen from that rock and not contaminants from laboratory air or from pollen present in the air while samples were being chipped from strata and put into plastic bags. It is this problem which we address in this paper.

Methods and Materials

In our experiments ordinary glass microscope slides were exposed to the atmosphere under various environmental conditions to determine the likelihood of pollen contamination. Sometimes the particular slide was greased with Vaseline to enhance pollen capture (Table I, Experiments 3-7) and on some occasions a slide was exposed without Vaseline (Experiments 1-6, and 9). In Experiment 8 double-coated scotch tape was placed on a glass slide instead of the Vaseline. On another occasion drops of water were added to the same spot on a slide at different times and were allowed to evaporate while the slide was exposed in a laboratory room for a total of 86 hours (Experiment 10). After