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GEORGE STARKEY, AN EARLY SEVENTEENTH-CENTURY AMERICAN ENTOMOLOGIST

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Between the earliest known North American entomological observations made by John White (Wilkinson, 1973a) and Thomas Hariot, and the beginning of more systematic investigations by John Banister (Ewan and Ewan, 1970) and other collectors in the late seventeenth and eighteenth centuries, especially those promoted by the London apothecary and naturalist James Petiver (Stearns, 1952; Wilkinson, 1966), a number of persons wrote about insects observed in British America. However, their remarks were usually very brief, and confined to notices of one or two species. Only a few seventeenth-century investigators actually studied North American insects and related forms *in situ* with any diligence. The earliest of these appears to have been George Starkey (1627 or 1628-1665).

Starkey, whose surname was Stirk before he changed it to the more familiar form seen on his title-pages, was the son of George Stirk, a Puritan minister in the Bermudas, and Elizabeth Painter. Leaving the Bermudas prior to 1643, Starkey finished his education in New England, and while at Harvard College began the study of chemistry and alchemy. Graduating in 1646, he took the master's degree "in course", and practiced medicine in the Boston area, where he married a daughter of Israel Stoughton.

In 1650 Starkey emigrated to England. Associating with Samuel Hartlib's circle of investigators, which in its scientific aspects has been interpreted as an informal, less secular, and more mystical precursor of the Royal Society of London, he engaged in a wide range of experiments, including the production of alchemical metals and the preparation of chemical medicines. Starkey's first publication was a long alchemical poem, *The Marrow of Alchemy* (London, 1654-55), which appeared under a pseudonym. With the appearance of *Natures Explication and Helmont's Vindication* he entered the dispute between those physicians who adhered to the "Paracelsian compromise" (Debus, 1965) and those who advocated more frequent use of chemical remedies. Starkey's book, an outspoken defense of the latter position, was followed by *Pyrotechny Asserted and Illustrated* (London, 1658), in which he continued the style of rhetoric which won him the friendship of only a small fraternity. Starkey's publications became more numerous during the vigorous medical-pharmaceutical disputes which followed the Restoration. He was among the relatively few physicians who remained in London to treat victims of the Great Plague in 1665, and was struck down himself at an unknown date, dying late in the year.

Starkey is best known as a physician and alchemist (Wilkinson, 1963), and it now appears that he may have been responsible for an important corpus of alchemical works which appeared under the pseudonym of "Eirenaeus Philalethes" (Wilkinson, 1973b). His role as a pioneer in American entomology has, however, gained scant notice. Although he wrote nothing concerning his entomological observations and experiments in the Bermudas and New England until 1655, Starkey told Samuel Hartlib in 1652 that "The Silke-Spider of Bermudas is hugely great. They Spin most excellent silke in great abundance," and gloves had been made of the product. The orb-weaving spiders, *Nephila clavipes* (L.), "far exceed the Silk-worms and may be kept also in old Engl[and]. They make their webs and that Strong ones between Tree and Tree" (Hartlib Papers, "Ephemerides," CC-CC₃). Hartlib was hoping to further the establishment of the silk industry in England, and he may have urged Starkey to undertake a paper on the Bermuda silk-spider; at any rate, one exists in title in Hartlib's papers (LX1, 2).

When Hartlib's interest in bees and the production of honey prompted him to publish a volume of correspondence on the subject, Starkey contributed two letters to *The Reformed Common-wealth of Bees* (London, 1655), which included further observations of the silk-spider and details of his experiments in the spontaneous generation of insects,

as well as his ideas on the cultivation of bees. Starkey noted that in the Bermudas there was "a sort of Spider, that is very large, and of admirable gay colours, yellowish, blackish, greenish, and reddish, so intermixed, that it makes the Creature very delectable to look on; these in great multitudes are there, who live abroad in the open fields, spinning their webbs from tree to tree of a vast bignesse, to catch Flies in, on the which they prey: their webbs are yellow, and most pure silk of which one Maid for tryall knit a pair of Gloves, which proved in wearing no whit inferiour to the best Silk of the Silk-worm. Now if these Spiders were so kept, as an ingenious man might easily invent, *they by feeding kept in good plight*, might be made to spin quantity enough, for as much as in few houres they will spin a large web, if their old one be taken away, else they mind onely their prey."

In his second letter, Starkey enlarged upon these observations; he was not sure whether the spider could be maintained in England, "yet in the Plantation, where they are naturally (being under this Government) I presume they might with ingenuity be made profitable; first, since they multiply so abundantly: Secondly, live in the open fields, not annoyed with weather: Thirdly, give Silk copiously, for out of one large Spider, in a day, one may draw at the least two drachms of Silk, if they have an intire Web they spend little after it is made, but if fed fat, they may be taken in ones hand, without danger to ones self, or dammage to the Creature, and one may out of its body wind a good ball of yellow Silk daily, which being washed is white enough. Fourthly, they will feed on Flies, or any blood of beast cloddered exceedingly, and all their nourishment may be forced out in Silk, which they as naturally made in their tail (which is a great bag, like a Pigeons Egge in bignesse) as Bees doe Honey." Starkey noted that silkworms were hard to keep, yet the Bermuda silk-spider was extremely hardy, "and who knowes what they may be brought to eat, I my self have fed them with pieces of Figs." One spider, Starkey thought, would yield more silk in a summer than six silkworms, "their Silk being full good as any" (Starkey, in Hartlib, 1655).

Starkey's account of *Nephila clavipes* was a reasonably accurate one for the seventeenth century, especially so when it is considered that he had not observed the insect in more than a decade, and it is interesting in the light of subsequent attempts to utilize *Nephila* silk. Starkey was not the first to notice the large orb-weaver in the Bermudas; Silvester Jourdan, who was shipwrecked in the islands in 1609, seems to have observed the yellow silk of *clavipes*, but thought it was produced by silkworms (Jourdan, 1610), and John Smith (1624) noted that in the Bermudas "Certaine Spiders. . . of very large size are found hanging vpon trees, but instead of being any way dangerous as in other places, they are here of a most pleasing aspect, all ouer drest, as it were with Siluer, Gold, and Pearle, and their Webs in the Summer wouen from tree to tree, are generally a perfect raw silke, and that as well in regard of substance as colour, and so strong withall, that diuers Birds bigger than Black-birds, being like Snipes, are often taken and snared in them as a Net."

The latter statement is somewhat of an overestimation, as were some of the claims made for *clavipes* by one of Starkey's contemporaries in the Bermudas, Richard Stafford. His account was sent in a letter to Henry Oldenburg, secretary of the Royal Society of London, in response to the Society's query about the natural products of the islands, and was printed in the *Philosophical Transactions* (1668). Stafford maintained that the spiders "spin their Webbs betwixt Trees standing seven or 8 fathom [*i.e.* 42 to 48 feet] asunder; and they do their work by spitting their Webb into the Air, where the Wind carries it from Tree to Tree. This Webb, when finisht, will snare a Bird as big as a Thrush" (Stafford, 1668). In the first lengthy account of the natural history of the Bermudas, John Matthew Jones cast the cold eye of nineteenth-century science on Stafford's account; "we think this statement to be an exaggeration; . . . we should be much nearer the mark if we were to place the greatest breadth at twelve to fifteen feet. Again, a bird the size of a thrush would easily break through the strongest web, and we believe it is only the small and barely full-fledged young of the white-eyed greenlet (*Vireo noveboracensis*) that has been known to become entangled in the meshes of this web."

Considering Starkey's successful attempt to reel silk directly from the spider, Jones' own experiment is relevant; "Being particularly anxious to test the strength of the silk, we one day caught an *Epiara* [*i.e.*, *N. clavipes*] and taking hold of the end of the silken thread hanging from its body, began to wind upon a piece of paper, and succeeded in obtaining a few yards of beautiful light yellow-coloured silk,—and this single thread was so strong that we could pull it slightly without breaking it. We were informed that the 'Mudian ladies made use of it for sewing purposes' (Jones, 1859). Burt G. Wilder, using South Carolina specimens of *clavipes*, had much better luck with a variation on the method described by Starkey; using a cylinder turned by a crank, he was able to draw strands up to three hundred yards in length from single individuals (Wilder, 1866).

Despite the warm hopes of Starkey and other persons who have advocated the commercial utilization of *Nephila* silk, production has never been sustained. Gertsch (1949) describes the uses of silk from *Nephila* species, chiefly by primitive peoples in Oceania, but suggests the difficulties that would be encountered in large-scale production. The animals are solitary, and could resort to cannibalism if confined together. Even if space and food requirements could be met, Gertsch calculates that these spiders would not be as productive as silkworms.

Starkey's observations of insects in the Bermudas and New England are quoted extensively from his first letter to Hartlib; concerning bees, he had "read in some Authors of their engendering out of dead Kine, fermented with the falling dew. Some think, that out of any kind of beast Bees may be produced, and doe conclude, that the Bees which bestowed their Honey on the carcasse of the Lion, slain by *Samson*, were of this nature, and bred out of that savage Creature, though I have known several sorts of dead Creatures both open, and covered with leaves, lightly [*recte* nightly?] exposed to the continual dewes, yet never could I take notice of any such procreation. And that out of Kine, either strangled, or otherwise dying, and so lying abroad, exposed to the influence of the Heavens, Bees naturally will not spring, I am induced: For that in the Summer Islands [*i.e.* the Bermudas], where I was born, I never yet saw one Bee, except those of a kind called Humble Bees, where notwithstanding, to my knowledge, divers Cattle both younger and elder, have (perishing by mischance, as it oft falls out there, that the very heat of the noon Sun in Summer kills Cattle if not removed into the shade) lye in the open fields till they have rotted, and have not a night scarce wanted the dew, in which Maggots and Wormes have bred, but no Bees, which if they were so to be bred, I suppose would in lesse than fourty yeares have been seen in those Islands, in which I never saw any, though I was naturally a great Observer of Insects there, where I noted Waspes, but no Honey making Bees. Nor is it to be thought, that the Climate is averse to the Generation of Insects, which it there produceth of other kinds as plentifully, if not more than many other places, in which Bees are.

Also my ingendred Curiosity was so great, that I took the pain to observe and collect the Generation of several Insects, with their various mutations from kind to kind, sparing no diligent travel that might benefit me herein. For so soon as I began to read a little in Philosophy, I took great content in these Contemplations, which after in *New England* I as carefully noted. In the Summer Islands I found, that in Rain-water kept in wooden Troughs (especially where the Sun at some time of the day shineth on it) there would in time gather a sedimen of muddy matter to the bottome, black and slimy, out of which would breed at the bottom, crawling long ill-favoured Wormes, with many feet: these Wormes growing bigger and bigger would swim and play together, and engender sexually, till at last growing more slow, they would at length lose almost all motion, at last coming to the top of the water, would by the legs hang near the superficies, where in few dayes, opening the back, out of them proceeds a Fly, which crawling out of the water, is for a day or two tender, after able to fly, which Fly, after a time casting its skin, becomes another creeping Insect, without wings, and out of it proceeds another Fly, farre different from the former. So in the ground, I have often under stones or tufts of grasse found tender Wormes, which are naturally in time of their own accord incrusted, and so lying a space, at length break, out of which comes a great Butter-fly, which layeth her Eggs on the Orange tender leaves, where the dew hatcheth them into Wormes, which live

on the leaves, and if touched send forth long red horns; these at length, hanging to the under part of a bough, are incrusted, and after a long death turn into the same kind of Butterfly, which before came out of the Earth.

Another sort of Wormes, ingendred by the Celestial influences in the Earth, being incrusted, proves a singing Fly, which after its season, cleaving to a tree casteth its skin, and of a Fly becometh a creeping sceptile [reptile?], and so liveth a long time, till about the season of the year when that Fly cometh again. This creeping thing on some tree or other for a time is almost without motion, at last bursting in sunder in the back, out of it comes the like singing Fly as came before out of the first Worm, which was bred in the earth.

Many such like Generations of Wormes in the Earth, and of crawling Creatures in the Waters, which after turn into Flies, and so again into other husky Wormes without motion, and from them to other flying Insects. I might speak largely, were it not besides my proposed intent and scope at present.

A third very anomalous Generation, which I have noted, is of a sort of stinging Flies out of rotten Trees: these, in the Summer Islands, I have observed out of the rotting Palmeto, and in New *England* I have seen the same in rotten Poplar and Birch: In which a man may at one time see some, like to a tender Spermatical milk, enclosed in a most tender skin, others like to a white Maggot, with a little motion, others now almost shaped like a Fly, others full formed, and able to crawle, others ready to come forth, and in a short time after to fly.

The Generations of Beetles, Dorres, &c. I have also diligently enquired into, and find, that under stone hedges, where dung-hills are usually made of Rubbish, they doe chiefly proceed, which some sort of Sea shell fish, buried in the Earth, doe also produce the same in kind and fashion with the former. Yet, as I said, I never yet could experimentally find any rise of Bees from putrefaction, though by me, for curiosity sake, oft attempted, and that with the bloud, also with the flesh of Kine, such as by accident perishing, I could procure part of them for tryall sake; this I have kept, some openly exposed to the dew, others covered with Rubbish (as for the Generation of other Insects) other while defended with green leaves and straw, and so buried in the Earth, others covered with earth immediately without any defence from the same, in which variety of operations, as I had variety of successe, at various seasons of the year, so never did the event answer the end, for which I employed this industrious inquiry. If any Gentleman, that hath on his own experience tried this manner of production of Bees, please to impart his method, I shall be unto him really thankful, and requite his communication perhaps with as acceptable a discovery.

Insects then in my opinion, is, as it were, Natures recreation, which she out of the fracid ferment of putrifying Bodies doth form, in which as there is singular and rare variety, so they are intended either as blessings or scourges to Man. The Bee, the Silk-worm, the Cochineel, how greatly profitable to Mankind they have been I need not repeat, nay most Insects of a shelly or scaly nature, being very excellent in medicinal qualities. I think then, that our sloth is very great, in that we neglect the inquiry into this particular" (Starkey, in Hartlib, 1655).

Starkey held to the ancient doctrine of the spontaneous generation of insects; only once in his account did he refer to sexual activity, and his observation in that case was mistaken. When he wrote his contributions to Hartlib's volume, the concept of spontaneous generation was giving way in the light of observational knowledge of sexual origins and insect metamorphosis. Yet the discoveries of such men as Redi, Goedart, Malpighi and Swammerdam were still in the future, and the standard authority on insects consulted by English scholars was Thomas Moffet's *Insectorvm sive Minimorum Animalium Theatrvvm* (London, 1634), which would appear in English three years after Starkey's account, and enjoy a new popularity. Moffet thought that bees were produced from cows, that beetles appeared by spontaneous generation, and that flies were engendered in similar fashion as well as sexually, although he had a reasonably accurate idea of the life-cycle of Lepidoptera. Although when Redi (1668) furnished his famous experimental disproof of the spontaneous generation of some insects (flies), it was readily

accepted due to the rapidly changing climate of scientific opinion (Hall, 1963), by no means was it forever certain that all small creatures had parents; Redi himself thought that larvae appeared spontaneously in plant galls, and the discovery of microscopic organisms led to a reopening of the controversy.

If Starkey's conclusions about the origin of insects were incorrect, at least he reached them from observation and experiment, and he was able to disprove the ancient myth about the origin of bees, although he did not reach the correct solution. His accounts of insect metamorphosis were sometimes quite faulty, although he watched representatives of a number of orders with some diligence. Perhaps this is explained by his statement concerning *Nephila clavipes*, that "I was not then so principled in Philosophy, when I lived in those Islands, as to observe every observable thing," but when one considers that all of Starkey's work in the Bermudas was conducted before he was sixteen years of age, he may certainly be excused.

In the remainder of Starkey's two published letters to Hartlib, he gave several other instances of what seemed to be spontaneous generation, including the production of an insect which appeared to have properties not inferior to the cochineal scale, and discussed his experiments to produce an oil of medicinal virtue from maggots (during which he thought he had engendered these larvae from decaying blood and liver); such unsavory medicines were not unknown to the seventeenth-century dispensaries. He wrote at length on the care of the honeybee and the production of honey, a subject in which he had practical experience, especially in devising ways of feeding bees. Starkey mentioned the appearance of raw beeswax under the microscope, although he did not say whether the observation was his own.

It is not known to what extent Starkey continued his work with insects and related forms after reaching England. Increasing involvement in matters of greater importance to him left little time for such pleasures; in his first letter to Hartlib he suggested that entomological investigations were "most applicable to a rural life, from which my profession is in a manner alienated." Yet many of his American observations are of considerable interest, ranging from his description of *Nephila clavipes* and its silk to his notice of the osmateria (scent horns) of the larva of the giant swallowtail *Papilio cresphontes* Cramer. Although he was not primarily a naturalist, George Starkey's contributions are important to the early history of American entomology.

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