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THE DEVELOPMENT OF LINNAEAN INSECT CLASSIFICATION

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If evolution by natural selection is one of the finest and most influential theories in the history of ideas, as I believe it is, its background surely deserves investigation. Wallace and Darwin and their correspondents had in common a view of nature, which I call the idea of classification. I use the word classification in its broadest sense, to include comparative anatomy, comparative embryology, and morphology. The idea is so fundamental and pervasive that it is hard to express it as a doctrine. Perhaps it is simply the conviction that there are real and important relationships in nature, not ecological ones, but relations of comparison. One of the most important elements, indeed probably the single most important, in the discovery of evolution by both Darwin and Wallace was geographical distribution. The other most important factor was a consideration of the fossil record. Yet, neither biogeography nor paleontology could yield anything suggestive whatsoever except within the context of the idea of classification. What arouses inquiry is the notion that different fossil species belong to the same genus or that South American and Galapagos birds belong to the same family. Perhaps this point is too obvious to need emphasis, but it may explain why I feel that a wider subject than the techniques of taxonomy should be studied, and why I feel that, when regarded as the structuring framework of that larger subject, taxonomy becomes a central thread in the history of Darwinism. I confess that my own fondness for the evolutionary understanding of nature and man is largely responsible for my interest in the history of zoological classification.

In the nineteenth century, the idea of classification was extremely powerful, both before and after the publication of the *Origin of Species* in 1859. The importance of earlier classifiers, and chief among them Linnaeus, to Lamarck, Humboldt, and Cuvier, would be hard to exaggerate. Yet this is sometimes forgotten. For example, Cuvier complained that the proliferation of nomenclators caused true science to be neglected, and that systems were merely the dictionaries of natural history – its means and not its end.[1] But simply to quote these complaints is to miss the point. The same youthful letters in which these remarks occur are totally crammed with the business of classification. Cuvier gives descriptions of new species in proper Linnaean form, he checks and evaluates the latest taxonomic monograph, he does his anatomical dissections as part of the systematic description of genera and orders and classes. His entire view of nature and of the discipline of biology is structured by classification.

How did classification grow in the eighteenth century to become the foundation of zoology in the nineteenth? Unfortunately, our picture of eighteenth century zoology is still very sketchy. Henri Daudin in 1926 cited many of the relevant sources, and perceptively described the conflicting demands imposed by the hierarchical order of method and the serial relations of the great chain of being.[2] But the subject deserves further investigation. How strong was the idea of a natural series? What did Linnaeus and his contemporaries see as the real goal of zoology? What is the nature of those "intuitions" which Daudin says play as large a role as ideas?

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1 The notes are given at the end of the article.

Daudin says that Linnaeus often chose poorly his characters for animal classification; for example, he divided insects according to their wings,[3] and he says that there was a tradition in France against classification, for example, in the work of the entomologist, Réaumur.[4] Since insect classification was a very challenging subject for Cuvier and his group, I wondered why Réaumur had been uninterested in it. The answer is simply that we ought not to equate Linnaean systematics with the idea of classification. Not only was Réaumur very interested in finding the natural (and hierarchical) order of insects, but so too did Linnaeus see that as his own prime goal and give it precedence over the logic of method. Zoologists could build upon Linnaeus' classification, exactly because it was *not* an artificial system based on the wings, but a sketch toward the natural order.

The reason Réaumur rejected the systematic model of John Ray's *Historia Insectorum* was that he wanted to excite a wide audience to an appreciation of the wonders of the insect world. He remarked that in spite of all the time and trouble it must have taken Ray to describe in such detail those hundreds of British butterflies, the resulting book was unreadable.[5] Ray's methodical tables and his scholarly Greek and Latin were not Réaumur's idea of style. He was not interested in enumerating every species of insect and made no effort to check his species against the literature. Yet for all his avoidance of the apparatus of taxonomy, Réaumur was committed to the idea of classification. His *Mémoires* are not simply a series of pleasant observations of where the wasp lays her eggs, how the cicada makes his noise, or what a mosquito does when it bites; his writings are pervaded by the belief that a scientific entomologist must understand the place of each species in the natural order.

The number of different insect species must be in the thousands, Réaumur knew, for they surely outnumbered the twelve or thirteen thousand plants already named.[6] The impossibility of remembering such numbers of things was throughout the century the most frequent argument given for the role of classification in natural history; the favorite metaphor of Linnaeus and his followers was that method was the thread of Ariadne. Without it, one was hopelessly lost in a confusing labyrinth. Even an artificial system which did not follow the order of nature would perform this valuable rescue mission. But Réaumur expressed the virtues of classification in quite different terms. The comparison Réaumur offered was not to the ancient myth of the minotaur, but to the latest mathematics. The number of insects might be almost infinite, but science could handle that.

> This is how one does sciences whose objects are infinite, like geometry, where the theory of curves contains an infinity of genera, and each genus an infinity of different species. When the general equation is found, which includes the properties of curves of a certain genus, when one can construct this equation, the problem is resolved, one is satisfied. It is a formula which one applies to several particular cases; one is even content to determine some of those points, of which one would have to determine an infinity to completely describe one of these curves; one leaves to those who have the need or the leisure, the job of applying the formula to other cases. A class and a genus of animals of which the characters have been well fixed, are for us what general formulas are for geometers.[7]

By deciding at the outset that he would not spend time and energy trying to record individually every single distinct species,[8] Réaumur was free to turn his attention to the higher categories. He dealt with single species as representatives of a *kind* of insect, because species belonging to the same genus differ only in such minor things as size or color. But there are groups of genera, and groups of these groups, and it is part of the scientific study of insects to discover the characteristics proper for identifying all these "classes" and "genera" of various levels.

Réaumur seemed to feel that the classes and genera he sought to characterize existed in nature and were not merely convenient abstractions. He used various striking and determinate qualities like shape of the body, kind of wing and how it is carried, or type of antennae, but these help us to *recognize* the group to

which an insect belongs; they do not *define* the group. We can learn to identify caterpillars by counting their legs, and so distinguish the larvae of butterflies from the larvae of beetles or flies, but we do not pretend to know the essential character of caterpillars: we do not know the *essence* of any animal.[9]

> The signs which are most convenient for us to distinguish insects from one another, those which are most within our reach, and which rarely deceive us, sometimes can deceive us: they are not always taken from that which constitutes the essential character. We recognize flies by their wings, but aphids and ants give us an example of flies to which wings have been refused. Likewise although we recognize beetles for what they are by the wing-cases, because all those we see are crustaceous, [nevertheless] we may not refrain from putting in the rank of beetles some soft insects whose whole exterior seems only to be membranous, and which, in short, have neither wings nor wing-cases. Such are the glow-worms of this countryside, which in spite of the little resemblance with beetles one finds in them, are nevertheless female beetles. From this we conclude, as we have already said more than once, that the essential character of each insect, does not always consist in what is best suited to making an impression on us. So it is too, apparently, with most organised beings, and the non-organised.[10]

This is about the extent of his explicit discussion of the philosophers' question about the relationship between definition and essence, but clearly, Réaumur believed that there was such a thing as a "beetle."

Because the wing-cases, or elytra, are so basic a character of beetles, Réaumur wondered what they were for. "We will not be so confident in thinking they are wing-covers," he says, "when we discover certain species in which they exist alone, with no wings under them." In the course of these wonderings, Réaumur began to ask himself whether the elytra were not a sort of wing themselves, so that beetles really have four wings. In Réaumur's understanding, this question could best be answered by finding out how the elytra function in flight. He cut off the elytra of large cockchafers in a series of elegant experiments.[11] His concern for classification had suggested an interesting investigation, but it is curious how far he was from distinguishing homology of structure from analogy of function.

The attention Réaumur paid to classification, and his assumption that natural groups existed, was not limited to remarks in his preface about order and method being necessary to scientific knowledge. Before proceeding to the natural history of various butterflies, Réaumur carefully itemized all the characteristics proper to different sub-groups. The recognition of an insect's proper place in the natural order demanded a close examination of its relevant characters, such as the type of antennae, the way the wings were held, whether it used all six legs or only four in walking, and whether the mouth had a sucking-tube or not. For distinguishing the various kinds of flies, he learned to examine their mouth-parts, and he carefully studied the presence or absence, the details of "teeth" or "trunk" of most of his genera. At the same time he felt able to take into account habit and general body shape, and he allowed any of his overall statements to have exceptions in particular cases.

Although Réaumur was writing for the general educated public, his readership did include some devoted collectors of insects. He had advised his readers to skip those sections which gave the characters useful in classification,[12] and was rather startled when a middle-aged noblewoman understood every detail and pressed him for more.[13] How seriously entomology could be pursued in the early eighteenth century may be inferred from a 1722 woodcut (see Figure 1), portraying a man, using a compound microscope to study the underside of what looks like a beetle. On his table is a similar insect, three or four other lenses, plus paper, pen and inkwell. He evidently kept his specimens in labelled drawers, as collectors still do. Frisch's published descriptions of insects suggests one of the problems this embryonic science would have to face. Frisch reported his observations simply in the order in which he made them. He wrote in German, and indexed his book by the insects' common names, or by the name he had just invented. Thus his careful and intelligent observations would be very hard

FIG. 1 – An entomologist in his study. This woodcut, first published in 1722, shows us the paraphernalia of a serious collector. His specimen drawers on the low bench are labelled "Scarabei majores" (large beetles), "Papiliones major" (large butterflies), and "Papiliones min[or]" (small butterflies). The chair holds drawers labelled "libella major" (large dragonflies), "vespae-major" (large wasps), "crabrones" (hornets), "Tipulae ma[jor]" (large craneflies), and "Muscae min[or]" (small flies). The drawers inside the cabinet are labelled "insecta aquatica". This little illustration (actual size 5.6 cm. by 10.3 cm.) decorates the beginning of Part 4 of Johann Leonhard Frisch's *Beschreibung von allerley Insecten in Teutsch-Land, Nebst nützlichen Anmerkungen und nothigen Abbildungen von diesen Kriechenden und Fliegenden Inlandischen Gewürmen,* published in Berlin in thirteen parts between 1720 and 1738. The artist was Frisch's son, Ferdinand Helfreich Frisch. Photographed by John J. Lupo, from a copy belonging to the Museum of Comparative Zoology at Harvard.

for another researcher to retrieve, and were in fact generally overlooked. A definitive ordering of insects could accomplish what an alphabetical index could not.

No sooner had Réaumur's first volume appeared than he found himself asked by collectors how their specimens should be arranged. His answer was that they could follow the plan of his books, but since it would clearly be many years before his ambitious project was completed (and indeed it never was), he would allow his readers to know at least his general intentions. After the butterflies and moths would come flies and ants, then insects with cases covering the wings (first with membranous covers, then those with hard opaque covers), then those with no wings, first with and then without a metamorphosis.[14] Whenever he deviated from his idea of natural classification, as when he considered together the various sorts of insects which cause plant-galls or leaf-deformities, Réaumur was careful to explain that a group was out of place and would be discussed again in its proper order. Réaumur seemed to have been feeling his way toward a detailed classification, but his text does contain ambiguities and remained incomplete, and he never set forth a neat table of divisions and subdivisions telling the collector where every genus should be placed.

Thus, although Réaumur had a strong interest in natural classification and even felt that one of his major contributions could be specifying which structural characteristics were most useful for such an ordening, he was not at all interested in constructing a system nor in describing every species. The contrast between

his narratives about the behavior of wasps and Linnaeus' Latin catalogues were evident to Réaumur's disciples.

Charles Bonnet had been entranced at seventeen by the *Mémoires*[15] and began his work in biology by repeating and extending Réaumur's experiments on the reproduction of aphids.[16] His praise for Réaumur was great, and included appreciation of his having "distributed in classes and in genera, by methods equally simple and brief," kinds of insects which had been in confusion.[17] But of Linnaeus, Bonnet wrote,

> What then ought we to think of those boasting *nomenclators,* or that [which] they presume to give us for the *system of nature?* Methinks I see a scholar undertaking to compile an index to a large folio volume; of which he has only read the title, and first pages. . . . I should have a greater esteem for a good treatise on a single insect, than for a whole entomological dictionary: because definitions and divisions are not history . . . I think we should be less eager to compile a catalogue of our attainments, than to augment them.[18]

Bonnet's belief in minutely graduated steps from species to species up a great chain of being did give him rational grounds for insisting that any division must be artificial, but that is not the same as saying that a division is undesirable; Bonnet suggested one for insects himself, and he certainly believed that some divisons might be consistent with the order in nature while others might be unfaithful to that order.[19] Bonnet's objection was not so much a logician's critique of the idea of classification as an experimenter's distaste for the task itself.

The terseness of Linnaeus' presentation obscured quite effectively the fact that his approach, at least for the insects, was fundamentally the same as Réaumur's, that is, to describe a group which he perceived, rather than to define a group by its diagnostic characters. His classifications of insects displayed as much or more concern with natural relations as with purely logical systematization. In his first *Systema Naturae* of 1735, Linnaeus' main purpose was to promulgate his sexual system of botanical classification, while suggesting a future program, a framework and an example, for systematizing the entire natural world. The insects occupy merely a third portion of one page.

This early arrangement is really quite a modest condensation of those few points on which previous entomologists were agreed. Linnaeus began with the strongest, safest group of all, the beetles. Insects with cases covering their wings had been christened Coleoptera two thousand years before, by Aristotle.[20] The most obvious thing to follow that with was the group of winged insects without wing covers that Ray and Lister had called "Anelytra."[21] But where the Englishmen had tried to incorporate the best of modern biology, taking into account Swammerdam's analysis of major differences in mode of development,[22] Linnaeus attempted no such sophistication. He simply lumped together the winged insects which weren't beetles, namely butterflies, moths, dragonflies, mayflies, lacewings, caddiceflies, bees, wasps, ichneumon, wasps, houseflies, mosquitoes, and crane-flies. He characterized them simply as being winged, without elytra.[23] There is a sense of natural unity to this group, for their wings are the first thing you notice about them, and they do fly.

Having dealt positively with so many common insects, all the "beetles" and "flies," Linnaeus was left with a miscellany. It was easy enough to follow both logic and his predecessors by putting the wingless ones last and labelling them "Aptera." Still, there remained some whose wings were not absent, just unimpressive, like crickets and bugs and ants. These he called "Hemiptera," which I think can best be translated "somewhat winged." This group can only be understood as the left-overs after he had blocked off the groups which nature seemed to have given him at the start. The grasshopper had a perfectly nice pair of wings, as he knew, but they were usually concealed under the tough upper wings. Bugs carried their wings tightly crossed across their back, so although they were not covered by elytra, neither were they freely displayed. The delicate wings of ants were not hidden when present, but apparently the overwhelming number

of wingless individual ants prevented Linnaeus from thinking of them in the same group as "flies," and they were consigned to the Hemiptera too.[24]

These divisions were as profound for entomology as would have been a botanical system dividing the vegetable kingdom into grasses, trees, other flowering plants, and non-flowering plants. One or two words stood for kinds of insects of which hundreds of species were already known; for instance, the genus *Papilio* included all the butterflies and moths in Ray's catalogue. Réaumur devoted two volumes to their biology, and Pierre Lyonet produced an extraordinary monograph on the anatomy of one caterpillar.[25] Bonnet had some basis for his sneer about an indexer of an unread book.

The task of recording every single species of insect seemed to Réaumur to be tedious, thankless, and probably pointless. Yet Linnaeus was audacious enough to undertake it. Over the next ten years, he compiled an ever-growing list of names, some of new insects collected by him or his students, some of insects already in the literature, and some from museums. Most of the species were not exotic but to be found in any European garden or field. By 1758, Linnaeus had named and catalogued about 1,900 species of insects.[26] The list he began has by now passed the million mark and is still growing.

In the *Fauna Svecica* of 1746, Linnaeus suddenly, with no explanation, considerably altered his classification. The changes, however, were not bold and incisive, but simply a delayed recognition of subgrouping of his "flies" which had long been familiar, not just to entomologists, but to casual observers. Butterflies and moths, christened by Linnaeus Lepidoptera, were an obvious group. The relationship linking bees and wasps had been noted by Aristotle, and their narrow waist helped give them a peculiar look; Linnaeus called them Hymenoptera. Two-winged flies, of course, had been separated by previous workers, and Linnaeus simply raised the status of his genus *Musca* of 1735 to create the order Diptera. The remaining "flies" had four membranous wings and an elongated body; he had listed them consecutively before, and now he named them, from the network of veins in their wings, Neuroptera. His group of left-over insects, Hemiptera, remained, or rather the name remained, while the content was revamped. Of its original seven genera, four departed to other orders, and five new genera joined the group. Linnaeus derived the name of each order from some quality of the wings; zoologists have ever since been grateful for his love of symmetry and euphony.

In 1758, Linnaeus included the following chart:[27]

4 wings
- superior
  - completely crustaceous ..... Coleoptera
  - semicrustaceous ..... Hemiptera
- all
  - covered with flat scales ..... Lepidoptera
  - membranaceous
    - tail unarmed ..... Neuroptera
    - tail with sting ..... Hymenoptera

2 wings, with halteres in place of hind wings ..... Diptera

0 wings, without wings and elytra ..... Aptera

But this analysis is certainly not at all a reflection of the process by which he perceived those orders. For instance, the genus *Coccus*, which he identified as having no wings in the female, and two wings in the male (he could even have seen halteres if he had looked), he placed with the Hemiptera, near other plant scales, gall-makers, and aphids, with which they have everything else in common, instead of with the Diptera, with which they have only the number of wings in common. He put the sheep-tick, which is wingless, in the Diptera (where it still remains). The value, strength, and success of these orders was that, having perceived and respected some natural groups, Linnaeus gave them a name. Christening the orders, not just the genera and species, was of enormous importance. The name belonged to the idea, to the perception. His chart was not a key by which

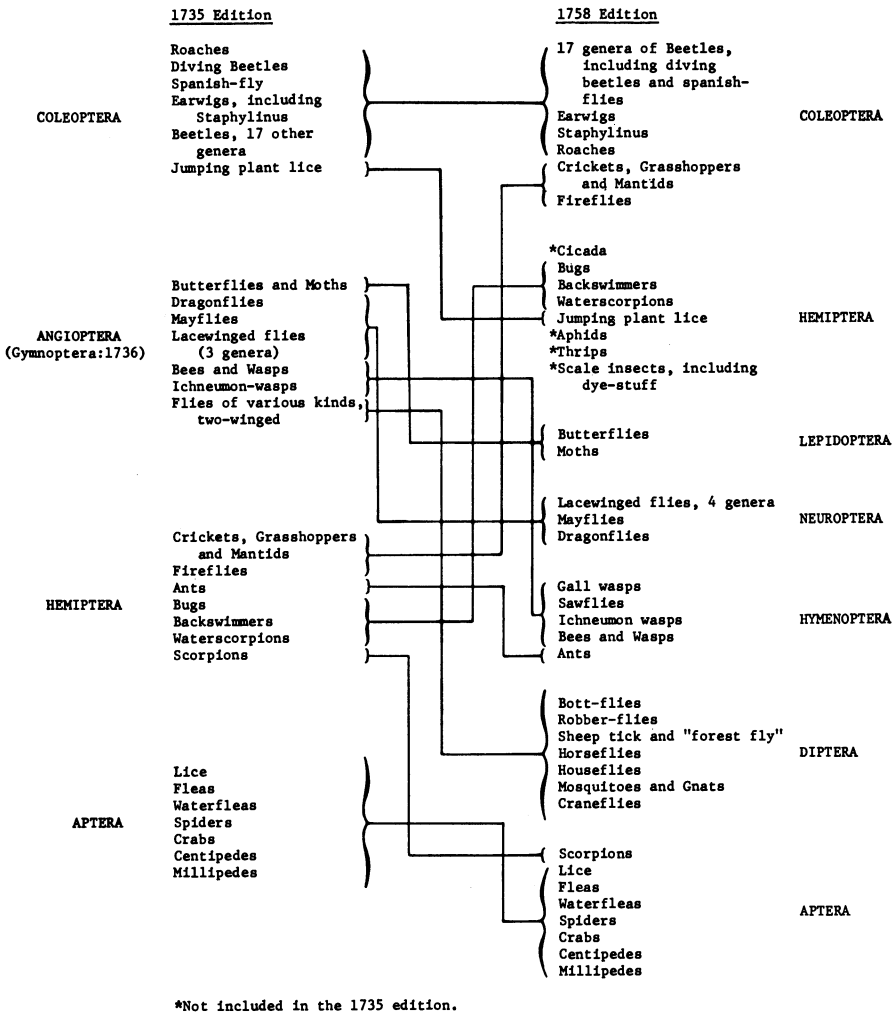


FIG. 2 – Insect Classification in *Systema Naturae*.

one could identify any insect, but was merely a schematic guide to the overall characters of the orders. Wings were not much good as the basis for a true artificial system. One of Linnaeus' most devoted students, Fabricius, spent a lifetime applying to insects the more perfectly methodical procedure which his teacher had preached in botany.[28] Linnaeus encouraged Fabricius,[29] fully aware that he himself had not constructed a *system* where orders were defined by the variations of one character.

Linnaeus' constant attention to nature's own arrangement may be seen not only in his identification of orders, but also in the sequence in which he listed the genera within these orders. His most stable order of insects, in terms of which species belonged to it, was the Coleoptera; it was stable, but not static. Those beetles kept changing places. At first they seemed to be playing musical chairs, but they settled down when they found their proper places. These changes were evidently necessitated by Linnaeus' concern for affinities and transitions. Prob-

ably the nicest illustration of that concern is his shuffling the fish around until the last one, just preceding the first insect, was the flying fish. After some rearrangement, the beetles began with typical genera and faded out with some insects which, beetle-like in some ways, have softer or smaller wing-covers. He moved crickets and grasshoppers out of the Hemiptera, so that they could sit next to the cockroaches, to whom they have a visible natural affinity. After these changes, his Coleoptera, which in one sense was a very tightly-knit group, had a smooth transition down to the four-winged insects (see Figure 2). He did not have to force nature, but because he was alert for transitional forms, the insects themselves led Linnaeus to regard elytra as a kind of wing.

In *Fauna Svecica* (and in the 6th and later editions of the *Systema Naturae*), why did Linnaeus move the order Hemiptera, which had followed after all those genera of "flies" which would become his four new orders? He shifted it to the head of that list, right after Coleoptera. Again, he seemed to be facilitating transitions. Indeed, the Hemiptera, which had come into being by default and whose fate seemed so uncertain, found a vitalizing *raison d'être* in the function of linking together more important and more natural groups. Bugs have wings which Linnaeus could call "semicoleoptera:" they are like elytra part of their length and become transparent the rest of the way. Once more we are reminded, though, that it was not really the wings which defined the order. He added to the Hemiptera aphids and related genera whose wings are totally membranous, but sometimes absent. The unifying character of the Hemiptera was its beak, a stiff tube with which the aphids pierce a stem to suck the plant juices, or the bedbugs suck the blood of their prey. The type of wing and sucking tube of the last members of the Hemiptera could then form a natural transition down to the next order.[30]

Though on one occasion, during Linnaeus' visit to France in 1738, he met Réaumur and admired his insect collection, there was a chasm between the two men, not only of language,[31] but of style and taste. But there was a bridge across this chasm in the person of the wealthy Swedish lord, Charles DeGeer. He knew Réaumur's *Mémoires* almost by heart and carried on an extensive correspondence with him, although I believe they never met. DeGeer modelled his researches directly upon Réaumur's, recording further details about species Réaumur had studied and making observations of other insects with the same attention to behavior, metamorphoses, and external anatomy. DeGeer even gave his volumes the same title, *Mémoires pour Servir à l'Histoire des Insectes.* He followed very closely Réaumur's classification; for instance, he started with butterflies, not beetles, and he divided his groups according to characters of the mouth as well as wings. But unlike Réaumur, he fulfilled his plan of discussing members of all the important genera of insects, completing the final volume at the end of his life. The chart of classification in this last volume seems very faithful to Réaumur's own vision.

DeGeer also corresponded with Linnaeus; indeed, he lived only a few miles from Uppsala.[32] It is my feeling that a comparison of their works and a study of their correspondence would show that because of DeGeer, Réaumur's insight and choice of diagnostic characters were incorporated into the formal systematics of Linnaeus. The classification of cicadas might be a good example. This genus of giant flies was overlooked in Linnaeus' first *Systema Naturae*; they had been mentioned in earlier literature, but Réaumur's memoir on them brought them into science.[33] Besides explaining the male's sound-organ, Réaumur used his microscope to discover that the cicada's mouth-parts consisted of peculiar, thread-like pieces held in a sheath. DeGeer added details of other species of cicada, but he also examined bugs, a group of insects Réaumur never got around to, and in these DeGeer noticed the same distinctive sort of mouth-organs.[34] It seems very likely that it was DeGeer's recognition of this relationship that was responsible for Linnaeus' placing cicadas next to other bugs in the Hemiptera. Many other features of Linnaeus' classification are certainly to be credited to DeGeer, and Linnaeus acknowledged his indebtedness.[35]

The idea of classification shared by Linnaeus and Réaumur grew to occupy a fundamental place in zoological thought by the end of the century. In 1802, the entomologist William Kirby was sure that the structure incorporated in taxonomy was the real structure of the living world, so that the Biblical description of God creating everything "according to its kind" may be understood to signify the distribution of all created species, not only into *Families* and *Genera*, but also into *Orders*, *Classes*, and *Kingdoms*; and so into a harmonious system . . ." like the natural system that classifiers strive towards, ". . . and both reason and observation unite in declaring that such a system, with its regular divisions and subdivisions, does exist . . ."[36] Much nineteenth century zoology was devoted to exploring the meaning of the agreed-upon reality of natural affinities. Lamarck insisted that affinities reflected the evolutionary order of production, while for Cuvier, the physiological integration of animals provided a physical, rather than metaphysical, explanation for the existence of distinct definable groups.

To a certain extent it is easy to see eighteenth century classification as a flower which would bear its fruit when Darwin published the *Origin of Species* in the nineteenth century. But this organic metaphor, like any description of history as growth or progress, is not really very satisfactory, for it emphasizes those elements of an age which seem important in retrospect. It does not explain what the early zoologists thought they were doing.

Although Linnaeus, Réaumur, and their colleagues did share an idea of classification, they could not be as positive about it as could William Kirby sixty years later. There was no reason to be certain that the thousands of unstudied species, from Europe and the rest of the world, would not obliterate rather than strengthen the groups they perceived. One thing above all that Réaumur learned from insects was to avoid dogmatism. His disciple, Lyonet, while avowing that a good methodical arrangement was much needed in entomology, declared,

> The Author of Nature, wanting in some fashion to make us see that he is the master of the laws and rules he has there established, sometimes seems to break them on purpose . . .[37]

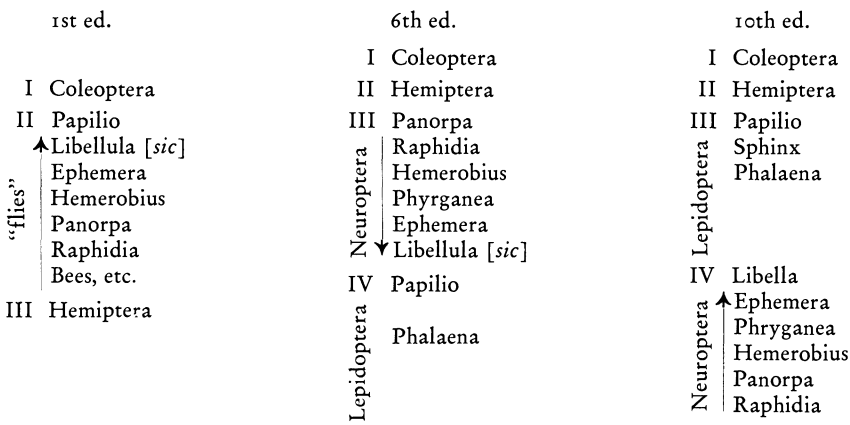
However reasonable or well-founded a system, it seemed there were always unpredictable exceptions. The humble aphid, now winged and now wingless, sometimes oviparous and sometimes viviparous, was an ideal warning against overconfidence in taxonomic reasoning.

If Linnaeus had been simply a transplanted Aristotelian, trying to capture the essence of species in logical categories, his accomplishments would hardly bear comparison in the history of biology with the experiments of Hales or Spallanzani, or the theories of Buffon. But classification was something more than either the observation or the theory it involved. As the entomologist, Geoffroy, pointed out, the charge that natural affinities might not be expressible by any classification did not touch the practical value of the enterprise.[38] As a system of citations and a technical language, it performed the critical function of joining naturalists together into a working community.

Réaumur and Linnaeus were united by a positive commitment, in which classification played a crucial role. Philosophers from Bacon to Descartes, and the achievements of the seventeenth century scientific societies, had demonstrated that science must not only be reasoned and methodical, must not only employ accurate observation, but must be the joint effort of a community of researchers. Individual observers of natural history, however clever, do not constitute a science of zoology. Underlying all the differences of style of Linnaeus and his contemporaries was a devotion to a common goal; their goal was no less than to make zoology truly scientific.

[1] Cuvier, Georges – *Lettres à C. M. Pfaff 1788-1792 sur l'histoire naturelle, la politique et la litterature.* Paris, 1858, p. 72.
[2] Daudin, Henri – *De Linne à Jussieu: Méthodes de la Classification et idée de série en botanique et en zoologie (1740-1790).* Paris, 1926.
[3] *Ibid.*, p. 70.
[4] *Ibid.*, p. 125.
[5] Réaumur, René-Antoine Ferchault de – *Mémoires pour Servir à l'Histoire des Insectes.* Paris, 1734, Vol. 1, p. 11. G. E. Hutchinson points out to me that there are not a hundred species of butterflies in Britain. Referring to Ray's "plusieurs centaines d'especes de Chenilles & de Papillons", Réaumur probably meant to include the moths (*Papillons nocturnes*). Further, both Ray and Réaumur recognized that there were different *kinds* of caterpillars, which increased the number of descriptions, though not the number of species. Counting butterflies, caterpillars, and moths, Réaumur's comment it not far off.
[6] *Ibid.*, Vol. 1, p. 2.
[7] *Ibid.*, Vol. 3 (1737), p. xxviii.
[8] *Ibid.*, Vol. 1, p. 3; Vol. 3, pp. xxvi-xxviii; Vol. 4, p. 147.
[9] *Ibid.*, Vol. 1, p. 67.
[10] Réaumur, René-Antoine Ferchault de – *Histoire des Scarabées (Encyclopédie Entomologique).* Ser. A, Vol. 32, Paris, 1955, p. 131.
[11] *Ibid.*, pp. 132-135.
[12] Réaumur, René-Antoine Ferchault de – *Mémoires* . . . Vol. 1, p. 41.
[13] *Ibid.*, Vol. 2 (1736), p. xiv.
[14] *Ibid.*, Vol. 4 (1738), p. xxvi.
[15] Torlais, Jean – *Réaumur et Charles Bonnet (d'après leur correspondance inédits).* Bordeaux, 1961, pp. 143-144, n.
[16] Bonnet, Charles – *Traité d'Insectologie.* Paris, 1745.
[17] *Ibid.*, p. vii.
[18] Bonnet, Charles – *Contemplation of Nature.* London, 1766, Vol. 1, pp. 170-171.
[19] *Ibid.*, Vol. 1, p. 240. Remembering his own criticism of taxonomy, Bonnet claimed that his classification of insects by their mode of development, based on Swammerdam's, was not "so much a division, as a mere table of *metamorphoses.*"
[20] Aristotle – *History of Animals.* Bk. IV, 7, 1; Friedrich Simon Bodenheimer – *Materialien zur Geschichte der Entomologie bis Linné.* Berlin, 1928, Vol. 1, p. 56.
[21] Ray, John – *Historia Insectorum . . . Appendix de Scarabaeis Britannicis, autore M. Lister.* London, 1710, pp. ix and 377.
[22] Swammerdam, Jan – *Historia Generalis.* Utrecht, 1669.
[23] In the 1735 edition of *Systema Naturae*, he calls this second group "Angioptera," a name which I cannot explain, but he immediately changed it to "Gymnoptera," expressive of the exposed wings (Linnaeus – "Classis animalia per sueciam observata," *Acta Literaria et Scientarum Sueciae,* Vol. 4, 1736, pp. 97-138.
[24] He included scorpions in the Hemiptera, because although specimens were wingless, it had been reported that winged scorpions did exist. Perhaps, like ants' wings, they were prone to drop off; he characterized them as having "loose wings" (*Alae* 4 laxae). He placed them after (truly winged) water-scorpions.
[25] Lyonet, Pierre – *Traité anatomique de la chenille, qui ronge le bois de saule.* The Hague, 1760.
[26] Bodemheimer, Friedrich Simon – *Materialien* . . . Vol. 2, p. 282.
[27] Linnaeus, Carl – *Systema Naturae: Regnum Animale* (Photographic facsimile of 1st vol. of 10th ed. of 1758, London, 1939 and 1956), p. 341.
[28] Fabricius, Johan Christian – *Systema Entomologiae.* Flensburg, 1775.
[29] Fabricius, Johan Christian – "Autobiography." *Trans. Entomol. Soc. Lond.* 4: i-xvi. 1845.
[30] Linnaeus does not explain why he arranged genera and orders in the sequence that he does. My reason for supposing that transitions were on his mind, is that at the same time (1746, *Fauna Svecica*) that he moved the Hemiptera up to the second slot, following beetles but ahead of "flies," he also rearranged the sequence of genera within the "flies,"

so that one with membranous wings and rostrum came first. When he later changed his mind about the arrangement of orders, reinstating butterflies as the first "flies," once more the sequence of genera shifted. The *relative* relations are retained, of butterflies to dragonflies at one end of the Neuroptera, and beaked lacewings to the Hemiptera on the other:



This example will not surprise anyone who has worked with the *Systema Naturae*, but is worthwhile reminding ourselves of the serial as well as the hierarchical dimension which classification can express.

[31] Torlais, Jean – *Réaumur*, pp. 199-200.

[32] In the preface to his *Fauna Svecica* (pp. xiv-xv), Linnaeus praised De Geer and credited him with giving Linnaeus the basis for many species and genera, as well as stimulating Linnaeus' interest in insects.

[33] Réaumur, René-Antoine Ferchault de – *Mémoires.* Vol. 5.

[34] De Geer, Charles – *Mémoires.* Stockholm, 1773, Vol. 3, p. 242.

[35] Linnaeus, Carl – *Fauna Svecica.* Preface [p. xiv]. Certainly the relationship worked both ways, and De Geer made his taxonomic categories, whether species, orders, or classes, much more explicit and exact than did Réaumur. De Geer declared himself determined to follow Linnaeus' good example by giving names to his new species, and he also imitated Linnaeus by giving abbreviated citations of other authors who had described a particular species. One might get the impression that De Geer, as an admirer of Réaumur, was rejecting or at least resisting the taxonomic forms of Linnaeus, since he used a one-or-two-line descriptive French phrase, rather than a Latin binomial, to name his species. Surely, though, these are not evidence of any such attitude toward Linnaeus, for he was only as slow as Linnaeus himself to adopt a consistent binary nomenclature.

[36] Kirby, William – *Monographia Apum Angliae.* London, 1802, Vol. 1, p. 2.

[37] Lyonet, Pierre – *Theologie des Insectes . . . Traduit de l'Allemand de Mr. Lesser.* The Hague, 1742, Vol. 1, p. 94.

[38] Geoffroy, Étienne Louis – *Histoire Abrégée des Insectes.* Paris, 1764, Vol. 1, pp. ix-xvii.