THE ARRANGEMENT OF THE MAJOR ORDERS OF INSECTS

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The relationships of the minor orders have been very frequently discussed, but that of the major orders have been given very scant consideration. The six major orders have been arranged in more than thirty different ways and in the last ten years fifteen authors have used ten different arrangements, half of which had not been employed previously.

The following table gives in chronological order the arrangements that have been used, the initial of the orders Orthoptera, R (Rhynchota) Hemiptera, Coleoptera, Diptera, Hymenoptera, and Lepidoptera, being employed to make a formula for each arrangement. The sign ‡ is used to separate those authors using the same arrangement but in the reverse order.

1735 C O R L H D (Aristotle, Aldrovandus) Linnæus 1735, Geoffroy 1764, Illiger 1798, Latreille 1796, Leach 1817, Lacordaire 1838, Harris 1841, Ruschenberger 1852.

1752 L H R O C D Degeer 1752, Olivier 1789.

1775 C O H L R D Fabricius 1775, 1787, 1792, Lamark 1819, Latreille 1821, Westwood 1839, Carpenter 1858, Gervais and Van Beneden 1859, Staveley 1871, Girard 1873, Le Baron 1874, Thomas 1876, Kirby 1892 ‡ Brumpt 1922.

1798 C O H D L R Clairville 1798.

1805 H C O R L D Cuvier 1805, Hagen 1863, Cook 1889.

1806 C O R H L D Latreille 1806, 1832, Percheron 1835, Snellen von Vollenhoven 1868.

1821 R O D H L C Oken 1821, Redtenbacher 1858.

1823 H C O L D R MacLeay 1823, Stephens 1834, Swainson 1835.
C O H R L D Kirby and Spence 1823, Dumeril 1823, 1860, Rye 1864.

1832 R O D L C H Burmeister 1832, Nicholson 1870, 1871, 1873, Carus 1880, Landois 1905 ‡ Dohner 1862, Sharp 1886.

1841 L D H C O R Newman 1841.

1849 L D R H O C Agassiz 1849 ‡ 1850.

1856 O R C D L H de Hoven 1856, Packard 1869, 1879, 1883, 1886, Kingsley 1884, Orton 1884, O'Kane 1912, Essig 1926 ‡ Packard 1863, Tenney 1865, Fernald 1884.

1864 H D L C R O (Ray) Dana 1864, Leconte and Horn 1883, Howard 1895 ‡ Kellogg and Doane 1915, Comstock 1924, Leonard 1928.

? D R L O H C Figuier.

1881 H C D L R O McLachlan 1881 ‡ Brauer 1885, Comstock 1888, 1895, Kellogg 1905, Folsom 1906, Herrick 1907, 1925, Wellhouse 1926.

1882 O C H R D L Mayer 1882, Shipley and MacBride 1901.

1885 O R D L C H Claus and Sedgwick 1885, Claus 1887, 1891, Blanchard 1890, Lindsey 1895, ‡ Mayet 1890, Riley 1892.
O R D C L H Balfour 1885, Sharp 1886.

1890 O R C L H D Hyatt and Armes 1890, Schiedt 1892, Smith 1897, Sanderson and Jackson 1912, Folsome 1922, Metcalf and Flint 1928.

1895 O C H R D L Hertwig 1895, Hertwig and Kingsley 1902.
O C H L D R Sharp 1895, Handlirsch 1903, 1923, Perrier 1904, Brues and Melander 1915.

1900 O R L H C D Davenport 1900.

1906 O R C D H L Woodworth 1906.

1908 O R L C D H Osborn 1908, Daugherty 1912, Sanderson and Peairs 1917.
O H C L D R Froggatt 1908, Lefroy and Howlett 1909.

1920 O R H L D C Crampton 1920.

1921 O C R L D H Fernald 1921, Lefroy 1923.

1923 O R H C L D Martini 1923

1925 O R L C H D Imms 1925.

1926 O R C H D L (Swammerdam) Tillyard 1926.

Only three authors had great influence on the arrangement of the orders. *Linnæus* separates those with thickened front wings: probably he also appreciated the coördinated thoracic structure, the large movable prothorax in one group and the consolidated thorax in the other. *Fabricius* combined the three mandibulate orders and the three haustellate, and finally *Oken* grouped together the four orders with complex metamorphosis and within this group the three dominant orders were brought together. He also maintained the proximity of the members of the Linnæan group with consolidated thorax.

These three men all antedated Darwin so that the arrangements in no case expressed any idea of phylogeny, and many later students probably adopted one arrangement or another without seriously considering questions of origin or development. The first evolutionist to suggest a new arrangement was Dana who adopted the sequence used by Ray and the last Tillyard adopted that of Swammerdam. Thus the arrangement that suited the sense of fitness of these great pre-Linnean naturalists corresponds with the ideas of students of phylogeny. Indeed, the general thought has been that the historic groupings, or at least some of them, were essentially natural.

The most decided trend after the days of Darwin has been towards the groupings of Linnæus and Oken and away

from that of Fabricius, which had previously dominated, because of the growing conviction that each haustellate order had an independent origin. This and the other trends can be best shown in tabular form, which gives the period during which each proposed arrangement was employed.

BASES OF ORDER GROUPINGS

Thorax	Linnæus 1735-1852
	DeGeer 1752-1789
	Latreille 1806-1868
	Newman 1841
Mouth	Fabricius 1775-1922
	Clairville 1798
	MacLeay 1823-1835
	Kirby and Spence 1823-1864
	Agassiz 1849-1850
	Figuier
	Mayer 1882-1901
	Hertwig 1895-1902
Thorax and Mouth	Cuvier 1805-1889
	Fernald 1921-1923
Thorax, Metamorphosis and Dominance	
	Oken 1821-1858
	Hyatt and Armes 1890-1928
Metamorphosis and Dominance	
	Burmeister 1832-1905
	Claus and Sedgwick 1885-1895
	Balfour 1885-1886
	Davenport 1900
	Martini 1923
	Imms 1925
Thorax and Metamorphosis	de Hoven 1856-1926
	Dana 1864-1928
	Woodworth 1906
	Crampton 1920
	Tillyard 1926

Mouth and Metamorphosis..... McLachlan 1881-1926
Froggatt 1908
Lafroy and Howlett 1909

Mouth, Metamorphosis, Thorax and Dominance
Sharp 1895-1923

Metamorphosis ..... Osborn 1908-1917

A conception of high and low development that came with the theory of evolution has had the most profound influence on classification as seen by the fact that only one of the pre-Darwinian arrangements began with the Orthoptera and this order formed one end of the series in every system but one that has been proposed since that period. Entomologists are practically unanimous in placing the Orthoptera lowest, but there is no agreement as to which order is highest, six selecting Hymenoptera, four favor Lepidoptera, the same number Diptera, two Hemiptera, and one Coleoptera. There is a fair degree of agreement regarding which order stands next to Orthoptera, twelve selecting Hemiptera, four Coleoptera, and one Hymenoptera, these latter five being those still clinging to the Fabrician division based on the mouthparts, while the majority favor the division based on metamorphosis following Oken.

There is an agreement among all recent students of phylogeny that each of the six major orders have been derived independently from lower forms, and difference of opinion as to the affinities and arrangement of these hypothetical ancestors explain in large part the diversity of arrangement.

The writer has suggested that a chronological arrangement be followed, since now for a good many years our knowledge of the fossils is adequate to permit of this arrangement. This does not apply to the minor orders in which the palæontological evidence may never be adequate. Handlirsch, who has given very great attention to the fossil insects, has clung to the arrangement of Fabricius, which has required the shifting of the Diptera and Hemiptera beyond the Lepidoptera. Had he set these where they

would come naturally according to his palæontological evidence, the arrangement would have been the same as that proposed by me. Tillyard, who has most recently proposed an arrangement, differs from my proposal only in the relative position of Hymenoptera and Diptera, which was based on newly discovered ancient fossils which he identified as hymenopterous, perhaps erroneously. Whether he is right or not, there is abundant evidence in the completeness of the differentiation of the families of Diptera in Tertiary times to establish its seniority to the Hymenoptera. The same kind of evidence makes Lepidoptera the youngest of all.

The chronological order permits the expression of all the accepted genetic relationships with the lower group as acceptably as any other, and is the only basis for the arrangement of the major orders, the adoption of which would result in uniformity. This order is

Orthoptera

Hemiptera

Coleoptera

Diptera

Hymenoptera

Lepidoptera