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.

<table>
<thead>
<tr>
<th>Year</th>
<th>Formula</th>
<th>Authors</th>
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<tbody>
<tr>
<td>1752</td>
<td>L H R O C D</td>
<td>Degeer 1752, Olivier 1789.</td>
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<tr>
<td>1775</td>
<td>C O H L R D</td>
<td>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.</td>
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<tr>
<td>1798</td>
<td>C O H D L R</td>
<td>Clairville 1798.</td>
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<td>1805</td>
<td>H C O R L D</td>
<td>Cuvier 1805, Hagen 1863, Cook 1889.</td>
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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.
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.
Only three authors had great influence on the arrangement of the orders. *Linnaeus* separates those with thickened front wings: probably he also appreciated the coordinated 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 Linnaean 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 *Linnaeus* 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**

- Linnaeus 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
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 palaeontological 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 evi-
dence, 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 identi-
fied as hymenopterous, perhaps erroneously. Whether he
is right or not, there is abundant evidence in the complete-
ness of the differentiation of the families of Diptera in
Tertiary times to establish its seniority to the Hymenop-
tera. 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