Exercise 2: Taxonomy, Nomenclature, and Identification of Major Insect Orders

What is taxonomy?

Taxonomy refers either to a hierarchical classification of things, or the principles underlying that classification. Linnaean taxonomy is a phrase used for the scientific classification widely used in the biological sciences. The underlying structure of the system was developed by Carolus Linnaeus, but its modern form is far more complex, and has been adapted to advances in biology. In the early history of taxonomy, scientists classified organisms into groups based on structural similarities. Today, we use biochemistry, behavior, fossils, molecular biology, and development to help us classify organisms along evolutionary lines. Much of this evidence also helps us reconstruct the evolutionary history of life. We assume that two different species that look similar share a common ancestor. Our taxonomic classification scheme should reflect that phylogeny, or evolutionary history. Taxonomy uses morphology as the most generally employed and readily studied way to place species into categories with other organisms sharing similar characters. A phylogeny is a hypothetical evolutionary tree of those organisms, constructed using lines of evidence from all disciplines of biology.

Nomenclature and Naming Conventions

Linnaean taxonomy classifies living things into a hierarchy, originally starting with Kingdoms. Today, many biologists consider Domains to be a classification above Kingdoms. Kingdoms are divided into phyla (singular: phylum). Phyla are divided into classes, and they, in turn, into orders, families, genera (singular: genus), and species (singular: species). Groups of organisms at any of these ranks are called taxa (singular: taxon), or taxonomic groups.

Linnaean taxonomy is a simple and practical system for organizing the diversity of living organisms. The most important aspect is the use of binomial nomenclature, the combination of a genus name and a specific epithet, to uniquely identify each species of organism. No two species can have the same binomial. In this way, every species is given a unique and stable name (compared with common names that are often neither unique nor consistent from place to place and language to language). This uniqueness and stability are, of course, a result of the acceptance by working systematists and taxonomists, and the complex codes of rules and procedures governing the use of these names.

Every new species that is discovered is described and identified, and then placed into groups that reflect their relationship to all other life on the planet. We then place those groups into larger and larger groups, thereby constructing a formal classification scheme consisting of a series of taxa (singular = taxon). Taxa have a hierarchy that progresses from very broad and encompassing categories at the top to very narrow and specific at the species level. Keep in mind that the species is a biological entity, and although all higher taxa reflect hypotheses about evolutionary relationships, they are mental constructs of humans. These hypotheses assume that all species placed within a higher taxa share a common ancestor at some point in the past.

There are numerous schemes, and phylogenies are often disputed, as you will see in lecture. This is partly due to the fact that some people are lumpers and some are splitters. That is, some people will tend to place one group of organisms together in the same group (the lumpers), while other people will take that same group and subdivide it into more than one group. Within Kingdom Animalia there are about 30 phyla of animals, but again, the number of

phyla in any scheme of classification will depend on the scientists that devised it. You will also see categories split into sub-categories, such as **subspecies**, **superphylum**, and **suborder**. The Insecta taxa has been given the rank of Class, Superclass, and Subphylum by different orders; part of why this has happened is due to our lack of knowledge of the true evolutionary history of the group, part of it is due to historic changes in that knowledge, and part is due to the organizational schemes of different taxonomists. Taxonomic groups can sometimes be dynamic at the higher levels; groups begin to stabilize at the lower levels.

Once we have an accepted scheme, we can devise **dichotomous keys** that we can use to classify specimens we collect. Different keys are used to identify organisms at different levels, from the kingdom to the species level. Today we will practice using keys at the order level, focusing on the orders of insects. All insects belong to the same Class or Subclass, depending on which scheme you are using. Our textbook puts insects in their own class (Insecta) within the Superclass Hexapoda, but Hexapoda used to be a class, with Insecta as a subclass. Note that there must be some other Classes (and Orders) that are Hexapods, but not true Insects. This indicates the dynamic nature of taxonomy and our understanding of relationships among species.

Nomenclature, the practice of naming species, has very specific rules for naming new species so that each new name becomes part of an integrated system that is globally recognized. Each name identifies the probable evolutionary relationship of the species, but the system is flexible enough to allow for disagreements and modifications of names. The **binomial** system of naming species is so called because of the convention of using both the genus and species designations in the species name. For instance, *Ochlerotatus triseriatus* (Say, 1823) is the scientific name for the eastern treehole mosquito. *Ochlerotatus* is the generic name and *triseriatus* is the species designation. **Carefully notice a number of things about the name.** First, the generic and specific names are always italicized or underlined. Second, the generic names always have the first letter capitalized and specific names are always lower case. Third, the full name also includes the name of the person (the authority) who first described and established the species and the year of the publication describing the species. In the case here, the authority and year are in parentheses because either the generic or specific name has been changed for this species since Thomas Say originally named it. If it has not changed, as in *Quercus rubra* Linnaeus, the authority is not in parentheses. Finally, the full name will also include the date that the description was published. For you, it will be sufficient to use genus and species only, but **you must remember to use both**, as specific names may be the same for species in different genera. You may abbreviate the generic name to the first letter, as long as there is no chance for confusion and the first time you use it, it **must be** spelled out completely. Also, if the name appears at the beginning of a sentence, do not abbreviate it.

International Code of Zoological Nomenclature

The International Code of Zoological Nomenclature is a set of rules that has one fundamental aim: to provide maximum universality and continuity in classifying all animals according to taxonomic judgment. The Code is meant to guide the nomenclature of animals, while leaving the zoologists some degree of freedom in naming and classifying new species. The rules determine what names are potentially valid for any taxon, including the ranks of subspecies and superfamily. Its provisions can be waived or modified in their application to a particular case when strict adherence would cause confusion. Such exceptions are made only

by the International Commission on Zoological Nomenclature (ICZN), which acts on behalf of all zoologists. The Commission takes such action in response to proposals submitted to it. Disputes are decided by applying the Code directly.

The entire code is quite long, and is published online at http://www.iczn.org. Here are a couple of rules, in addition to the ones mentioned above, of which you should be aware. The first published description of a species fixes the species epithet; if the species is later moved to another genus, it retains the first-published epithet unless that would create a homonym. Two examples illustrate this rule. First, the common chimpanzee was named *Simia troglodytes* by Johann Friedrich Blumenbach in 1799; Lorenz Oken moved it to the new genus *Pan* in 1816, so the valid name is now *Pan troglodytes*. Second, a species of Madagascar snake was given the name *Xiphosoma madagascariensis* by Gabriel Bibron in 1844. Kluge moved *Xiphosoma madagascariensis* to the genus *Boa* in 1991, but there was already a snake named *Boa madagascariensis*, which is a case of an invalid junior secondary homonym. So Kluge gave the species the replacement name *Boa manditra*. The movement of a species to a different genus or family reflects new information regarding phylogeny of the species – in other words, **taxonomy should reflect evolutionary history**.

In zoological nomenclature, author citation refers to the person (or team) who first publishes a scientific name of a taxon in a peer-reviewed publication. The author, or authority, of a taxon is referenced for three levels of taxonomic rank: 1) family-group names, at the ranks of superfamily, family, subfamily, tribe, subtribe, 2) genus-group names, at the ranks of genus and subgenus, and 3) species-group names, at the ranks of species and subspecies. Within each group, the same authorship applies regardless of the taxon level to which the name is applied. For example, the red admiral butterfly is assigned to Family Nymphalidae Swainson, 1827. The subfamily to which it belongs is written Subfamily: Nymphalinae Swainson, 1827, as is Tribe Nymphalini Swainson, 1827. The genus is *Vanessa* Fabricius, 1807, and reference to the species is *Vanessa atalanta* (Linnaeus, 1758). The brackets around the author citation in this latter case indicate that this is not the original taxonomic placement. In this case, Linnaeus published the name as *Papilio atalanta* Linnaeus, 1758, but it was later placed in a different genus, one that was originally named by Johan Christian Fabricius.

In citing the name of an author, the surname is given in full, not abbreviated, with no mention of the first name(s), with only a couple of exceptions. One of those is Linnaeus – he named so many species, that it is common practice to simply use L. or (L.). If the same surname is common to more than one author, initials are given. The date of publication is usually added, although many journals have dropped that requirement, with a comma between the author and date. If the authority is in brackets, so is the year of first publication. The taxonomist making the decision to effect the move is not cited.

Quick Overview of Insect External Anatomy

Read Chapter 2 in Gullan and Cranston (2005), and bring it with you to lab for this exercise. Much more detail is given there. What follows is a superficial treatment of external anatomy.

The chief characteristics of insects are **three pairs** of walking legs, **one pair** of **antennae**, a body typically divided into three regions (**head, thorax, and abdomen**), and a respiratory system composed of tracheal tubes. Although most insects have either one or two pairs of

wings, the wings are present only in adult stages and there are many insects that are wingless as adults. Most insects are quite small, being less than 2.5 cm in length, but there are some large and robust insects, and many also have much larger wingspans than their body length.

Be aware that once you begin to identify insects to the family level you will encounter terminology specific to particular orders, for structures that appear only in that taxon or for structures that are evolutionarily modified in that order. For instance, the forewings of beetles (Order Coleoptera) are modified to serve a protective function and are called elytra. Many insects have characteristic hairs or bristles that are used in identifying families, genera, or species. In these cases, it will be to your advantage to have your textbook or some other reference handy to look up terms you find in keys. Many of those references will be available.

All insects have a chitinous exoskeleton, which is composed of hard plates called **sclerites**. Sclerites are bounded by sutures of soft cuticle, which are important in allowing flexibility. Generally, the sclerites are also separated by the segmentation of insects. Segmentation is reduced somewhat in some insects and in some body regions, but the thorax always consists of three segments. The thorax is where legs and wings are connected. One pair of legs is attached to each of the three segments, which are called **prothorax**, **mesothorax**, and **metathorax**. The two wings, if present, are attached to the posterior two segments (meso- and metathorax). In the head segmentation is often reduced and difficult to observe externally. The abdomen consists of between seven and eleven (generally) segments, depending on the order, but they are generally easy to distinguish. Spiracles, openings to the tracheal system, are often visible on abdominal segments. This is a very basic description of external anatomy – be sure to consult your text and the references available in the laboratory for more information on external anatomy and terminology.

Introduction to Dichotomous Keys

A dichotomous key is constructed with a series of couplets, which is a pair of phrases consisting of two mutually exclusive statements. From the characters described in each couplet you should be able to choose one of the statements as the one that best fits your specimen. You then follow the key to the next couplet, make a decision, and continue until you identify the unknown specimen. For instance, to identify a wolf, we might use the following key:

Couplet	1a.	vertebrate	Phylum Chordata: 2
	1b.	invertebrate	50
Couplet	2a.	possesses hair	Class Mammalia: 3
	2b.	no hair	15
Couplet	3a.	predatory; teeth adapted for tearing flesh	Order Carnivora: 4
	3b.	herbivorous, non-flesh eating	Order Rodentia: 10
Couplet	4a.	claws retractable	Family Felidae: 9
	4b.	claws non-retractable	Family Canidae: 5
Couplet	5a.	solitary	6

5b. social animals; live in packs wolves

(Note that this key is incomplete and there are more orders within the Mammalia and more families within the Carnivora than are shown here.)

By reading each pair of statements, you proceed through the key to more narrow and specific characters, until only a single choice remains. In the above example, which is not complete (and is not meant to be), couplets direct the reader to another couplet, until one of the phrases of a couplet is a trait that only one species possesses. Couplet 2, for instance, divides all the chordates into two groups, the ones without hair and the mammals. The choice of that phrase and ones after that leads the reader to identify their unknown. As long as the correct choices are made and the unknown species is in the key, then a confident identification can be made. Today we will practice using dichotomous keys for a group of insects. This will help prepare you for one of your term projects: developing an insect collection.

Assignment

Identify, to the order level, the **twenty (20)** insect specimens available in the laboratory. Make sure you identify the specimen number with its order, so that I can verify your identification. You'll have available the keys and glossary of anatomical terms that you will need to help you identify the specimens. This introduction to insect external anatomy and terms will be useful when you begin to identify specimens for your collection. You should hand in the assignment at the end of lab.