ANIMAL INTERACTIONS

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No animals live without contacts of some sort with other animals. Contacts between two animals may be by chance crossing of paths, or for cooperation in mutual purposes, or in competition to fill some need, or for exploitation of one by the other. Most animals have contacts of some sort with a considerable variety of others, as predator, as prey, as mate, as offspring, for competition for space and shelter and food, or for some of a wide variety of other purposes.

In contemplating these interactions, it has been possible to group them under certain words, such as symbiosis, commensalism, parasitism, predation, reproduction, and so on. The animals show so many variations and combinations of these that the words have come to have somewhat indefinite and varying meanings. There has seemed to be confusion over the relations involved, although this is surely due principally to the inadequacy of the terms.

An unrestricted tabulation of the associations or interactions between any two animals shows these to be far more diverse than is usually made clear. Most animals have associations of many sorts, both with their own kind and with other kinds, and for the most part these relations are of similar sort within the species and between species. We have therefore intentionally left the matter wide open, treating all associations of any two animals without initial regard to whether they are of one species, two related species, or species in separate phyla. The possibility of producing complexity or confusion by this broad approach seems to have been escaped, and in any case it is overridden by the advantages of seeing the total picture of animal relationships.

Animal associations could be classified on any of these aspects:

1) Genetic relationship (of same species, of different species, or of different groups)
2) Purpose (accidental, cooperative, competitive, or exploitative)
3) Product or result of the inter-action (reproduction, food, space, shelter, labor, transport, construction)
4) Stage of life cycle (of either animal)
5) Who is benefited
6) Duration (momentary, temporary, permanent)
7) Intent or choice (chance meeting, planned meeting, automatic position)
8) Specificity (random animals, always same species, always same two species, one of a variety of species)
9) Fatality (death of one inevitable, severe damage possible, slight damage, no measurable damage)
10) Others

What makes tabulation necessary is that associations occur in a variety of combinations of these aspects. In these multiple-aspect cases (especially in exploitation) the importance of the different aspects also varies widely, greatly increasing the diversity in associations. The resulting associations defy classification, because intermediate examples are almost always found if sufficient search is made. The diversity of relationship is a reflection of the diversity of the animals, in which behavior is an important aspect. The way of life of a lion, a leaf-mining insect, a tapeworm, a colonial bryozoan, a jellyfish, and an amoeba are diverse, but when some of the relatives of these live in competition and exploitation with their own and other kinds, the diversity of behavior is many times multiplied.

The accompanying table is really two tables in one, first for the cases where the two animals belong to one species and second for the cases where they belong to different (usually widely different) species. These two are combined to show both the similarities in the two lists and the differences between them. Annotations and examples are used for amplification.

This tabulation does not bear out our initial expectation that the great diversity in animal interactions would make it impossible to use clearly the customary words. The only well-known word which finds no place in this chart is symbiosis, which by its inherent meaning (living together) should be used to cover all cooperation between and all exploitation of actual animals of different species. For the rest, the usual terms in reasonably restricted meanings find logical places in the diagram (different species). A few varieties of interaction are not covered by any of the usual terms, and many are covered only by the most general one (symbiosis).

There is sometimes a temptation to supply new terms for ideas or situations not covered by old ones in such an analysis. We think this would be futile, because even these do not cover all the possible interactions, and the diversity of animal behavior will defy all regimentation in such a set of terms.

Most biologists restrict all these terms to interactions between individuals of different species (the right-hand column). In this treatment the following would be the major types:

Mutualism, which is actually mutual exploitation
Competition, for shelter, food, or territory
Exploitation, among which are included:
For food:
Predation
Micropredation
Ectoparasitism
Endoparasitism
Commensalism
For transport:
Phoresy
Domestication
For other purposes:
Domestication
(others without specific terms)

The word parasitism should logically be restricted to ecto- and endoparasitism, as exemplified in ticks and tapeworms, respectively. The use of the word parasitism in entomology, however, is well established for a quite different situation. In an effort to avoid this difficulty, some entomologists have switched to the term parasitoidism for the "parasitic" insects such as Hymenoptera. This still hides the real nature of the relationship, which is that of a predator on the early stages of the life history, not that of a parasite (either ecto or endo-). Micropredation is exactly correct for this situation and is therefore preferable to either of the others in those insects which do kill their "hosts" (prey).

The purpose of this paper is to point up the diversity of animal interactions and the inadequacy of the existing definitions to group them. Further terms will not cure the inadequacy, but an understanding of the existing diversity of interactions would help to prevent inadequate communication caused by understatement of the diversity and oversimplification of the relationships.

All Associations

ACCIDENTAL (passive)

same species

Aggregations (usually in competition)

Colonies (Bryozoa, corals)

different species

(Apparently all can be called Purposeful, as competition for space, at least, is always involved)

PURPOSEFUL

Cooperation

Bisexual reproduction
Societies
Colonial division of labor (reproduction, feeding, protection, locomotion)
Grooming

Cooperation

Mutualism (= mutual exploitation)

Competition

Shelter, food, territory, mate

Competition

Shelter, food, territory

Exploitation

For food
Normally fatal
Cannibalism

Normally not fatal individually
Transferring digested food
— — —

Secretions (milk)

Endoparasitism

From tissues (egg yolk)

Exploitation

For food (all metabolic needs)
Normally fatal
Predation
Predator/prey (carnivores)
Micropredation
Embryonic predator, in egg, larva, or adult (wasps, flies)

Normally not fatal individually

Ectoparasitism
Occasional blood-sucking visitor (mosquito)
On surface; hair, scales, feathers, skin, exudations (lice, mites)
Endoparasitism
In surface tissues; follicles, gills (chiggers, glochidia)
In ectodermal passages (tongue worms)
In digestive tract lumen (tapeworms)
In internal tissues or organs (eye worms, sporocysts)
In body cavity (larval tapeworms)

In particular organs (endoparasitic males, human foetus)	In particular organ lumen; gonad, lung, bladder (giant kidney worms) In vessels or ducts (trypanosomes, flukes, nematodes)
— — —	Commensalism In faeces, internally (protozoans) Outside, for stolen or lost food (pilot fish, jackal)
For shelter (all physical needs) On parent (opossum young) In host (endoparasitic males) In parent's shelter (house, den, tube) In parent's "shadow" (parental protection)	For shelter On host (barnacle on whale) In host (fish in sea cucumber cloaca) In living host's shelter (worm tubes) In host's "shadow" (a fish living among the tentacles of *Physalia)*
For care of non-feeding polymorphs (colonies)	— — —
For use of labor	For use of labor
For use of labor Slavery Digestion of food (fed to young) Care of young	For use of labor Slavery, domestication Digestion of food (by intestinal biota) Care of young (slave ants, cuckoos)
— — —	For camouflage (sponge on snail shell)
For transport (Mammal carrying young)	For transport: Phoresy To another host; to food source, to another site (phoretic insects, man on horseback)
For use of constructions Abandoned nests & dens Re-use of zooecium	For use of constructions Abandoned nests & dens Hermit crab in shell
For control by social hormones (termites)	— — —
For control of caste by feeding (ants, termites)	— — —
For use of transplanted organs (Crustacea, man)	For use of transplanted nematocysts (flatworms, ctenophores, nemerteans)
For man's purposes Esthetics, experimentation, sport, commerce, religious sacrifice	For man's purposes Esthetics, experimentation, sport, commerce, religious sacrifice, medicine

MULTIPLE ASSOCIATIONS

(Always divisible into pairs and therefore treatable above)