XIII  Ecological implications of parasitic castration of animals

A. "Fate worse than death" to the parasitized population
   1. Effects of predators upon prey species
      a. Victims killed
         (1) Don't reproduce (negative effect)
         (2) Removed from habitat
      b. Less inaspecific competition for survivors (positive effect)
         (1) More food available
         (2) More space available
      c. Surviving prey have more resources
   2. Effects of parasitic castrators upon host species
      a. Victims alive
         (1) Don't reproduce (negative effect)
         (2) Remain in habitat
      b. Competition not reduced (negative effect)
         (1) Less food available
         (2) Less space available
      c. Unparasitized members of host species have access to fewer resources than if parasitized had been removed from habitat - "Fate worse than death"

B. Two genotypes possess one phenotype or "When is a crab not a crab?"
   1. Textbook definition of a species
      a. "A group of individuals capable of interbreeding under natural conditions"
      b. Reproductively isolated from other such groups
   2. Unparasitized crabs do NOT interbreed with crabs parasitized by rhizocephalan barnacles
   3. In a reproductive sense a crab parasitized by a rhizocephalan is not a crab, but a completely different species, a barnacle.
   4. Parasitic castration results in a situation where two different genotypes (host and parasite) possess the same phenotype (that of the host)

C. Competition interactions
   1. Competitive exclusion
      a. It is assumed that if 2 species compete for the same resource, one of them will usually be driven extinct
      b. Members of one species will exploit the resource more effectively & be able to survive on a lower level of that resource
   2. Character displacement
      a. Definitions: Two species are sympatric when living in same geographic range & allopatric where each lives separately
      b. Studies (i.e. birds on islands) have shown that the difference between characters often increases where species are sympatric
due to interspecific competition) compared to the same characters where those species live alone (due to exploitation of a larger niche).

D. Effects on hosts parasitized by rhizocephalans of the family Sacculinidae (Is character displacement occurring here?)

1. Hosts are castrated
   a. Reproductive organs don't mature
   b. Hosts will acquire the external morphology of adult crabs

2. Male crabs become feminized
   a. Females have a wide abdomen or "apron" that covers egg mass
   b. Infected males will acquire an abdomen wider than that of males, but often not as wide as that of females

3. A crab with an externa will not molt
   a. Barnacle will molt following release of larvae
   b. Since both host and parasite are crustaceans with homologous endocrine systems, it is puzzling as to how growth is inhibited in one and occurs in the other

4. Parasitized crabs bearing externae are significantly smaller than unparasitized adults

E. Examples of parasitic castrators

1. Nematoda, Order Mermithida
   a. Juveniles
      (1) Parasitize invertebrates
      (2) Fill body cavity
      (3) Host moves to water before emergence
      (4) Kill host when emergen
         (a) Ecologically similar to parasitoids
         (b) Biological control
            i) Mosquitos
            ii) Fleas
   b. Adults do not feed

2. Nematomorph = "Horsehair" or "gordian" worms
   a. Larvae
      (1) Obligate parasites
      (2) Fill body cavities of large invertebrates such as crickets, millipedes, shrimp
   b. Adults
      (1) Free-living
      (2) Do not feed
      (3) Found in aquatic environments such as . . .
         (a) Streams
         (b) Horse & cattle troughs (hence the common name)
         (c) Wells
         (d) Ocean
c. Effects on hosts
   (1) Parasitic castrators
   (2) Terrestrial hosts enter water just before mature worms emerge
   (3) Emergence of adult worms causes death of host

3. Insects, Order Strepsiptera (Twisted-wing parasites)
   a. Parasitize insects
   b. Life-cycles
      (1) Free-living Juveniles = Triungulin larva
          (a) 0.2 mm long
          (b) Remain on vegetation
              i) Jump in response to movement/shadow
              ii) Enter body of host
      (2) Molt & become legless larva
          (a) Feed on host tissue
          (b) Pupate w/in host
      (3) Adult males
          (a) 2-3 mm in length w/ large membranous wings
          (b) Leave host after pupation
          (c) Free-living
      (4) Adult females
          (a) Do not pupate
          (b) Remain in host as larviform adult
          (c) Protrude from abdominal segments of host
          (d) Male mates w/ female in host
   c. Effects on host
      (1) Normal life-span
      (2) Morphology (color) changes = "stylopization" become masculinized
      (3) Sex organs do not mature

4. Crustacean Copepod, Cardiodectes
   a. Infect deep-sea lanternfish
   b. Head of copepod penetrates heart of fish
   c. Reproductive organs are outside host
   d. Parasite feeds on blood of host
   e. Host is castrated

5. Crustacean Isopod
   a. Same order as terrestrial pillbug or "rolly-polly"
   b. Body is flattened dorsal-ventrally
   c. Suborder Epicaridea
      (1) Parasitic castrators of crustaceans
      (2) Sex determination
          (a) First parasite to arrive becomes female
          (b) Second parasite attaches to female and becomes
male

Family Bopyridae
(a) Gill parasites of shrimp and crabs
(b) Infected hosts recognized by swollen gill chamber
(c) Feed on blood of host
(d) May castrate by placing nutritional drain on host

Family Entoniscidae
(a) Most are internal parasites of crabs
(b) Some hyperparasitic on rhizocephalans

6. Barnacles of the order Rhizocephala
a. Life-cycle
(1) Adult releases two larval forms
   (a) Male and female
   (b) Larval forms are typical of barnacles which is why there are classified as barnacles

(2) Infection of crab host
   (a) Female larva finds vulnerable host
   (b) Molts to a specialized stage shaped like a dart
   (c) A cell is injected into host that will become the parasite

(3) Interna
   (a) Parasite grows along host intestine
   (b) Sends roots throughout host body
   (c) Interna is the internal stage of parasite

(4) Externa
   (a) Host undergoes a molt in which it acquires the adult morphology
   (b) A extension of the parasite extrudes from the exoskeleton in the abdominal cavity where the host normally carries eggs called virgin EXTERNA
   (c) Male larvae lands on virgin externa and injects primordial sperm cells
   (d) Externa grows and becomes a sac containing the reproductive organs of the parasite

(5) Adult parasite continuously releases broods of larvae

b. Specific interactions between the rhizocephalan, Heterosaccus californicus, and the spider crab, Pugettia producta
(1) Mean size of adult unparasitized crabs was significantly larger than parasitized crabs
   (a) No difference measured in growth rate
      i) Molt increment
      ii) Duration between molts
   (b) Parasitized crabs passed through fewer instars (underwent fewer molts) than unparasitized crabs
before acquiring the adult morphology

(2) Parasite found in only the southern range of the host (Fig. 1)
   (a) Range
      i) Host ranges from Southern Alaska to Mexico
      ii) Parasite found from Central California south
   (b) Prevalence (%) of parasite in host population (Fig. 2)
      i) Highest levels of infection in south
      ii) As one went north, infection levels decreased steadily

(c) Specific interactions between the rhizocephalan, *Loxothylacus texanus*, and the blue crab, *Callinectes sapidus*

(1) Range of the parasite restricted to southern region of the host distribution (Fig. 3 compare with Fig. 1)
   (a) Parasite is restricted to the Gulf of Mexico
   (b) Host ranges extends along Atlantic Coast to New England

(2) Generally the highest prevalences of the parasite are found in the northern portions of the Gulf of Mexico. (Fig. 4 compare with Fig. 2)

(3) Parasitized crabs are smaller than unparasitized (Fig. 5)

(4) Infection levels correlated with temperature: Colder (lower) temperatures lower the infection rate
   (a) Effect of temperature on host & parasite reproduction (Fig. 5 & Table 1)
      i) Both reduced in colder water
      ii) Assuming temperature is the important factor, why would it be more important to the parasite than host
         a) Suitable habitat for host is present all year
         b) Suitable habitat for parasite (i.e. a vulnerable) is not always present
   (b) CRITICAL DENSITY HYPOTHESIS
      i) Parasite must maintain concentration of infective larvae above a *critical density* to ensure that the minimum number of *vulnerable* hosts are infected in order to complete the life-cycle
      ii) This assumes that host vulnerability to parasitization is ephemeral
         a) Perhaps only newly molted (soft-
shell) crabs are infected

b) Perhaps only small crabs can be infected