NOTE: These pages are the handouts that accompanied the November 17, 2011, Parasitology seminar entitled “Metaparasitology.” Links to the pdf of the PowerPoints and the audio from that seminar are on my blog (below).

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TO:

FROM: JJJr.

RE: My notes of the Thursday discussion, which may not relate much to what was actually said

Big ideas in parasitology - discussed at Barry's, December 28, 1995 (not necessarily in order of size or importance; nor are they necessarily mutually exclusive):

(1) What is the genetic structure of parasite populations? (or, What is a parasite population?)

This question really addresses the matter of the evolving unit among parasites, or the potential evolving unit. In other words, is each host individual an island among an ever-changing population of islands? etc. etc.

(2) What restricts gene flow in parasite populations?

This question is somewhat related to the first, but has the added quality of being addressable in insect parasite populations, in which, potentially, the geography of parasitism on a small scale can mimic the large scale geography of parasites in vertebrates.

(3) What is the relationship between morphological difference and genetic difference, i.e. is the magnitude of phenetic difference correlated with the magnitude of genetic difference, among parasite populations, species, etc.

This question has already been answered, of course, for some distantly related vertebrates, as well as for higher taxa, by the molecular evolutionists. HOWEVER, it really needs to be addressed at low taxonomic levels, e.g. populations and species, in order for us to get a serious and meaningful handle on evolutionary processes in parasites.

(4) How do the above questions and problems apply to specialists vs. generalists? Other evolutionary important categorizations of parasites?

(5) How rapidly can evolution potentially occur in parasites?

For example, can we do the selection experiments with parasites similar to those done with *Drosophila*? And if so, which systems would be the most informative, most easily manipulated, etc.?

(6) Why do some host species harbor rich parasite communities and others habor only impoverished communities? In other words, is there a hospitability factor OTHER than ecological ones (e.g. breadth of feeding niche)?

There is a philosophical component to this question, namely whether there is a physiological property that's the theoretical equivalent of size (in islands).

(7) How stable, genetically, are parasite populations?

This question is really a version of (5) although there may be some undiscovered components to it.

(8) What is the effective size of a parasite population?

It's not real clear whether this is a real question.

(9) What is homology? How to determine homology? What is homologous?

These questions are, of course, the classic ones biologists have struggled with for centuries. The issue for the parasitologist is to come up with specific traits to which to apply the questions. Life cycle events?

(10) Philosophy - Discuss the problem of tractable systems. (JJ - especially the way it influences large scale thinking?)

(11) How DO parasites evolve, really?

Maybe a more tractable version of some of the above questions?

(12) Why the negative binomial?

Is there some grand aggregating principle? Aggregating mechanism? How do non-vagile organisms become aggregated? Are vagility and generalism factors that contribute to aggregation? (JJ - these are still good questions; they also, however, carry an enormous amount of baggage from the Robert May crowd and all its descendents and hangers-on.)

Janovy lab--Research problems and interests May, 1996

The following is a list of possible research problems appropriate for both undergraduates and graduates. These are problems that I feel I have the intellectual resources to direct, and for which we have the necessary space and logistical support. This list is certainly not exhaustive; it's simply representative of the kinds of work we do, the kinds of systems we use, and the conceptual contributions possible. In most cases, I've made some comments about feasibility, glamour, etc. These ideas are not arranged in any particular order; in fact they're on the page more or less in the same sequence that they occurred to me or were developed from various conversations with other parasitologists. I've developed a rating system as follows:

* = paradigmatic and eco-behav-evolutionary glitzy
** = exceptionally educational regardless of glitz
*** = especially challenging; not for the faint hearted or those who worry about their futures.

Insect/apicomplexan systems:

(1) Selection for susceptibility and/or resistance in hosts:*/**

(a) does selection for adult susceptibility influence larval susceptibility?
(b) can one separate breeding lines into high and low susceptibility?
(c) does the *Te.molitor* parasite community behave in the same way as the parasites of *Tr. confusum* in this regard (keeping in mind that in *Tribolium* the same species parasitizes both larvae and adult, while in *Tenebrio molitor* that is not the case)?

(2) Selection for a temperature resistant strain of *Gregarina triboliorum*: */**

Not really sure what the context for this project would be, but it's entirely possible that an evolutionarily important study could be built on this idea.

(3) Spore chain makeup, percentage mature, percentage exporulating at certain times, spore longevity, etc., all done in a comparative way.*/**/***

The problem here is developing the assay methods. But there is some real evolutionary potential here that is biochemically heuristic. Spore maturation may be an evolving developmental process. Clopton has done the preliminary conceptual work on the *Te. molitor* system, but there are a great many others, possibly in orthopterans, that are worth looking at.

(4) Colonization and establishment of colonies and trading of infections:*/**/***

(a) The setup is a series of containers with media, some with beetles, some without, etc.
(b) Utilize cones to allow movement one way but not another? Will these work? What kind of controls, experimental design, does one use? Can we measure colonization rates?

GIVE SOME THOUGHT TO WHAT KINDS OF PRINCIPLES MIGHT BE EXPLORED WITH THIS SIMPLE TECHNOLOGY.

(5) Inbreeding/outbreeding of parasite lines--obtain these through use of single vs. 2 or more gametocysts as sources of spores.*/**

The problem here is to figure out exactly what to measure to convert this kind of system into a significant evolutionary problem.

Can this set of experiments be combined with the selection ones in order to multiply the importance of an evolutionary study??

(6) Does infection affect mate choice?*/**

Tribolium is the animal of choice, here; especially using some strains with physical genetic markers and demonstrated equivalent fecundity.

(7) Effect of parasitism on the reproductive success of *Ischnura verticalis.*/***

Damselflies are beautiful, the work falls into that glitzy realm of sexual selection, but is complicated enormously by certain damselfly behaviors.

(8) Damselfly-gregarine coevolution:**

This problem is one truly fine doctoral dissertation for someone who doesn't care a whole lot about his or her future employment chances. Conceptually, this one is truly excellent and could probably be done at the MS level, too.

(9) Dragonfly gregarine survey and experimental infections:***

The question of why damselflies have such a diversity of parasites and dragonflies do not may be a good evolutionary question.

(10) Damselflies--mechanisms by which adults become infected:**

A simple problem??

(11) *Gregarina niphandrodes--Te. molitor* relationships revisited:**

Answer the question: do the most highly infected members of a population produce offspring which are themselves the most highly infected members, etc. This problem is actually the same as the one above, but with the added component that one could ask whether any observed increased susceptibility in the adult carried over to the other species in the larvae.

Gregarine ideas – May, 2001. All of these require some detailed planning and forethought.

(1) The Stockland experiments: Somebody needs to repeat the Renee Stockland experiments in which she was actually able to calculate the probability of infection based on amount of food intake in early *Tenebrio molitor* larvae. This work is fairly close to publication stage, and another couple of runs would generate the necessary data. Whoever does this work needs to put Renee's name on as second author. The big conceptual question is: *Is probability of infection actually related to the concentration of infective stages in the environment*? Actually, by individualizing the larvae the work would be strengthened quite a bit, and the complementary experiments could also be done with adults, although the setup gets fairly large in that case. The project requires some TLC and coordination efforts and is a little bit labor intensive.

(2) Single gametocyst infections: This may be a waste of time and a bad idea, but there may also be some merit in doing some experimental infections with oocysts from a single gametocyst, as opposed to two or more gametocysts. The big conceptual question is: *Must a host get parasites from more than one gametocyst in order for the life cycle to continue*? This project would become a rather spectacular one provided one eventually discovered that gregarine species differed in terms of the mating type makeup of single gametocysts.

(3) The inheritance of susceptibility: This project is a relatively time consuming and lengthy one, but needs to be done, and probably could actually be done, although it is far more labor intensive than one might think at first. The big conceptual question is: *Do individual beetles differ in their ability to host gregarines, and if so can such difference be used to generate High Susceptibility Lines (HSL) and Resistant Lines (RL)*? The corollary questions are actually the interesting ones: *Does an HSL selected and bred using adult* T. molitor-G. niphandrodes *also exhibit high susceptibility to* G. cuneata *in the larval stage*? and *What form does the resistance actually take in a RL, e.g. failure to establish, failure to grow, failure to carry out syzygy, etc.*? In a fantasy world, a person could use various RLs to dissect the host-parasite relationship and discover exactly why a particular parasite was dependent on a particular host.

(4) Comparative mating behavior of gregarines: This is actually Rick Grimm's project, and it has all the potential for being a real glamour project, although it looks like probably there are only two general kinds: early and late.

(5) Surface architecture of gregarine oocysts: This involves some SEM work, and is something that Josh Krejci has sort of started on. The interesting question is whether one can associate certain oocyst-environment interactions with surface architecture, e.g. one might ask are *G. niphandrodes* oocysts non-wetable because of their surface ridges? Nevertheless, a set of 20 different SEMs would make a truly glamorous presentation, both in a meeting and in print.

(6) Comparative host specificity of gregarine species in *Tribolium* spp.: This is the doctoral dissertation from hell, with truly major evolutionary implications, and we have all the

materials. It is not an easy task and is highly labor intensive. There is quite a bit of preliminary work done on the taxonomic part, which will likely turn out to be a rather substantial undertaking.

(7) Male/female host differences in susceptibility: I honestly believe there may be something interesting here, and it could be done with several species of beetles already in culture in the lab. In particular, the relationship between sex and female breeding condition might be interesting, if for no other reason that it might show hormonal effects on parasite life cycles. However, there is a whole lot of slop in this research, and that will likely prove frustrating.

Some relatively creative ideas, for which the big conceptual context will need to be written (although it's not terribly difficult to do so.)

(8) Parasite establishment conditions: There is some anecdotal evidence, going back to Clopton's experimental infection efforts, that the condition of a beetle's gut, i.e. what it's been eating recently, has a significant affect on whether or not gregarine infections can establish from oocysts. This idea could be explored using recently emerged adults, two or three different diets, etc.

(9) Physical texture of food vs. parasites: In old colonies, in which the larvae are eating mainly their own feces, the infection rate with *G. cuneata* tends to be very low, whereas under some other conditions (don't really know what those are??), infection rates and parasites/host tend to be very high. When you cut open a larva that's been eating mainly larval feces, its gut is filled with gritty, coarse, stuff. There is something here, namely that specificity can be a function of physical texture of food, although hard-nosed experimentalists will shoot some holes in the work if you don't have the right controls (which will be very very difficult to produce).

(10) Transfer of parasite species: This is really a far-out idea, but one could probably try to transfer gregarine trophonts from one species of insect to another, or from one life cycle stage (e.g. larva) to another (adult), just to see if the infections would take. The big conceptual issue would be the basis for host specificity, and would, if the infections took, show that establishment, not on-going nutrition, etc., is the "developmental lesion" that produces host specificity. It would not take very much time and effort to try this [probably really stupid] idea with *G. cuneata* transferred to adult *T. molitor*.

(11) Host specificity between *Stylocephalus* spp. and *T. molitor*: Somebody needs to do this simple experimental infection just to see if it would work.

(12) Mitosis in gregarine trophonts: If one could stimulate mitosis in gregarine trophonts, by some artificial means (ideally very simple), it would be a truly magnificent accomplishment for a variety of reasons. This idea is worth some thought, some very serious thought, if for no other reason than that the conceptual contribution is so great it's worth a gamble just to see if it can be done. Somebody needs to bring up this idea at a Coffee House gathering.

The different forms of Parasitology:

ELEMENTAL PARASITOLOGY: What species is Parasite X?

RAW UNCUT PARASITOLOGY: What is the relationship between Parasite X and Host Y?

METAPHORICAL PARASITOLOGY: How does Host Y defend itself against Parasite X?

POLITICALLY CORRECT PARASITOLOGY: Why does Host Y reject Parasite X?

THEOLOGICAL PARASITOLOGY: What behavior does Host Y exhibit that predisposes it to infection with Parasite X?

ECONOMIC PARASITOLOGY: What is the cost of the relationship between Parasite X and Host Y?

SOCIAL PARASITOLOGY: What is the population structure of Parasite X in a sample or population of Host Y?

POLITICAL PARASITOLOGY: Who is Host Y (given Parasite X)?

SAFE ALTRUISTIC PARASITOLOGY: How can we rid the Host Y population of Parasite X? (Or, Host Y must be suffering from Parasite X, so we must relieve Host Y's suffering.)

SENTIMENTAL PARASITOLOGY: What is the safest anti-helminthic to use to rid Puppy Y of Parasite X?

PEDAGOGICAL PARASITOLOGY: What aspects of the Parasite X/Host Y relationship are we responsible for on the next exam? (Or, generalized: what do we need to know about Parasite X?)

MILITARY PARASITOLOGY: What's the most effective way to prevent most of Host Y from getting Parasite X in the next 60 days?

PHILOSOPHICAL PARASITOLOGY: What entities share properties with Parasite X?

THEORETICAL PARASITOLOGY: How can I publish a paper without actually handling either Host Y or Parasite X?

BULLYING PARASITOLOGY: Why are you studying Parasite X when everyone knows that Parasite Z is far more important?

INTERNET PARASITOLOGY: Parasite X is so damn cool!! Host Y sucks! (42 characters; Twitter)

How to envision this course: FROM THE FIELD PARASIT MANUAL

There are a number of ways to envision the Field Parasitology experience; a few of them are:

(1) As a course in humility and patience.

One of the first lessons we learn is that not all plans involving natural materials are easily carried to completion. Thus we are likely to have some class days that simply are not successful for a variety of reasons. My hope is that you will be patient with me and with yourselves when this happens, and take the experience as an authentic lesson in biology, as opposed to the often contrived biology lessons you get in city campus labs. You will also discover that joint efforts, involving a number of people from different backgrounds working toward a common goal always (*always*) take longer to complete than you think they should. Again, patience helps when class days get very long.

(2) As a course in public health

For those of you with interests in the health professions, Field Parasitology probably comes as close as you will come, unless you enroll in a public health program somewhere, to a course in epidemiology, disease distribution, infection rates as influenced by "social" factors, etc. The analytical tools we use in this course are very similar, and in some cases identical, to those used by professional epidemiologists. Indeed, some of the field exercises are very good mimics of tropical medicine research and epidemiological studies.

(3) As a course in microecology

We routinely analyze numbers, distributions, and population structures of parasites that occupy small animals such as insects, crustaceans, and fish. These hosts represent small, patchy, and ephemeral habitats that are occupied by even smaller organisms, their parasites. Thus we tend to use general ecological principles and techniques, and apply them at a microscopic scale.

(4) As a course in biodiversity

By definition, a study of parasitism involves a study of both the host and the parasite, thus two species, and their respective biologies, contribute to the relationship. The widespread (taxonomic) distribution of parasitism means that in five weeks a student can encounter a very large number of species from several phyla.

(5) As a course in pathology and diagnosis

Again, for those with interests in the health professions, Field Parasitology can be thought of as a continuing effort to discover "who" is infected with what and what the effects of that infection might be.

(6) As a course in invertebrate zoology

Many of the hosts we study, and all of the parasites, are invertebrates. You will constantly be asked to lean anatomy, taxonomy, identification, natural history, and ecology of invertebrates. The anatomy in particular may prove to be a challenge for some of you (as well as your instructor).

(7) As a course in the use of the microscope

Field Parasitology will constantly test your microscope skills. It is to your advantage to develop your instrumentation skills, and to work hard at learning to use this most common study device (the microscope). Development of a sense of how to use this instrument will pay off many times during your career.

(8) As a course in teaching

Field Parasitology is designed to illustrate general principles through use of short field exercises. The choice of biological materials is critical to the success of this endeavor. For those of you destined for the teaching profession, this course should help you learn to design studies that rely on easily available biological materials and integrate field work, identification, hypothesis testing, and data analysis.

(9) As a course in learning to deal with complexity

Parasite life cycles, communities, and invertebrate anatomy can all seem highly complex at first, mainly because the animals we encounter are often exotic and small. I try to help students get through their initial shock by (1) repeating certain experiences until these experiences become familiar ones, and (2) asking that you try, early on, the tasks that seem most difficult and unfamiliar.

(10) As a course in learning to generalize

The widespread distribution of parasitism means that you will see the same general phenomena manifested in several different animal groups that at size and numerical scales that vary over an order of magnitude or more. My hope is that you will learn to recognize general phenomena regardless of the scale and circumstance under which they are manifested.

Questions Regarding Gregarine Biology

✓✓1. What are the different strategies of different species of gregarines in achieving equal distributions in their hosts?

a) Are there differences?

✓2. Can gregarines affect their hosts' behaviors?

✓✓3. How many species of gregarines are there in the prairie system presently under study?

✓4. Can one manipulate sporogony and schizogony to affect transmission strategy?

* 5. What would have been an ancestral form to sporozoans (gregarines)?

a) Gametocyst development suggests what? Comparison to ameboid cysts?

* 6. Would the sporozoan combination of sexual/asexual reproduction give a hint to the emergence of sexual reproduction? -- How could genotypes for sexual reproduction compete with those for asexual reproduction given the 1/2x advantage of asexual means over sexual?

*✓7. Is a gregarine really a parasite?

✓8. What is the cost of the gregarines to its host?

✓✓9. How host specific are gregarines?

✓10. What is the function of the apical complex?

* ✓11. What are the explanations for gregarines only parasitizing invertebrates?

✓12. Should the genus Gregarina be cleaned up? Or is it actually more than the catch-all for new species?

* ✓✓13. What are suitable characteristics for a gregarine classification key?

✓14. Does gregarine movement say anything about a possible ameboid ancestor?

* 15. Would a cladistical analysis (choosing/comparing characteristics) show any new relationships between gregarines?

* ✓16. How does the biological species concept affect a protozoan like a gregarine?

✓17. Would distributions of gregarines from different geographic areas (but same taxonomic host group) show any patterns of host biogeography?

✓✓18. Are there gregarines deposited in any collections at the present?

19. Can one manipulate gregarines in the lab to select for or against any one kind of variance between them?

✓20. Would a marine environment show different distribution patterns of gregarines than seen in a terrestrial habitat? (Oligochaetes, Polychaetes)

What are the justifications of studying a "mundane" group like gregarines, given no economic or human health angle? Is "just Because" enough? Or "Because I want to" ?

✓ = not worth the expenditure of time re a MS thesis project for various reasons, e.g. the technology does not exist to explore them, etc.

✓✓ = Profitably can go with thesis work

* = Worthy of intellectual $, i.e. intell development, expenditure of time & effort & reading.