9.20 M.I.T. 2013

Lecture #18

Mating and Reproduction

—introduction—

Scott ch 8, Reproductive behavior

About evolutionary dynamics

1. In discussions of evolution, one hears the terms "natural selection" and "sexual selection". Contrast these terms. Give examples of a behaviorally related trait that evolved by natural selection and of one that evolved by sexual selection.

   (See p 168 "concept" box.)

   For each trait, what are the likely costs? benefits?

"Costs" here means reductions in the individual's likelihood of passing on its genes. "Benefits" increase the likelihood of passing on the genes.

For a trait to evolve, benefits must exceed costs.

Scott ch 8, Reproductive behavior

About evolutionary dynamics

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   (See p 168 "concept" box.)

Trait(s) that evolved by natural selection: Most traits, including alarm calls of various monkeys, ground squirrels and other species; ability for remembering food storage locations; anti-predator actions; a great many other traits that benefit an individual's survival for reproduction.

Traits due to sexual selection: The tail feathers of male peacocks or pheasants; the red color of the male cardinal; the long tail of swordtail fish, the lion's mane, a stag's antlers. These traits benefit reproduction by making the male more attractive to the female. Female characteristics can also be shaped by sexual selection when males exercise choice.

[For each trait, what are the likely costs?]

Birds of Paradise, male and female

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Paradesia decora
(Goldie's bird of paradise)

Birds of this group are found mainly in New Guinea. Some are found in the Moluccas (an archipelago within Indonesia) and in eastern Australia.

(We saw a videoclip of one of these birds, the Paradise Riflebird of Australia, before the midterm.)

Why do you think the elaboration of the male feathers has gone to such extremes these birds?

-- Few predators, if any.
-- The plumage does not interfere very much with their foraging & feeding.

Peacock and Peahen

Illustration removed due to copyright restrictions.

From "Wildlife of Pakistan"

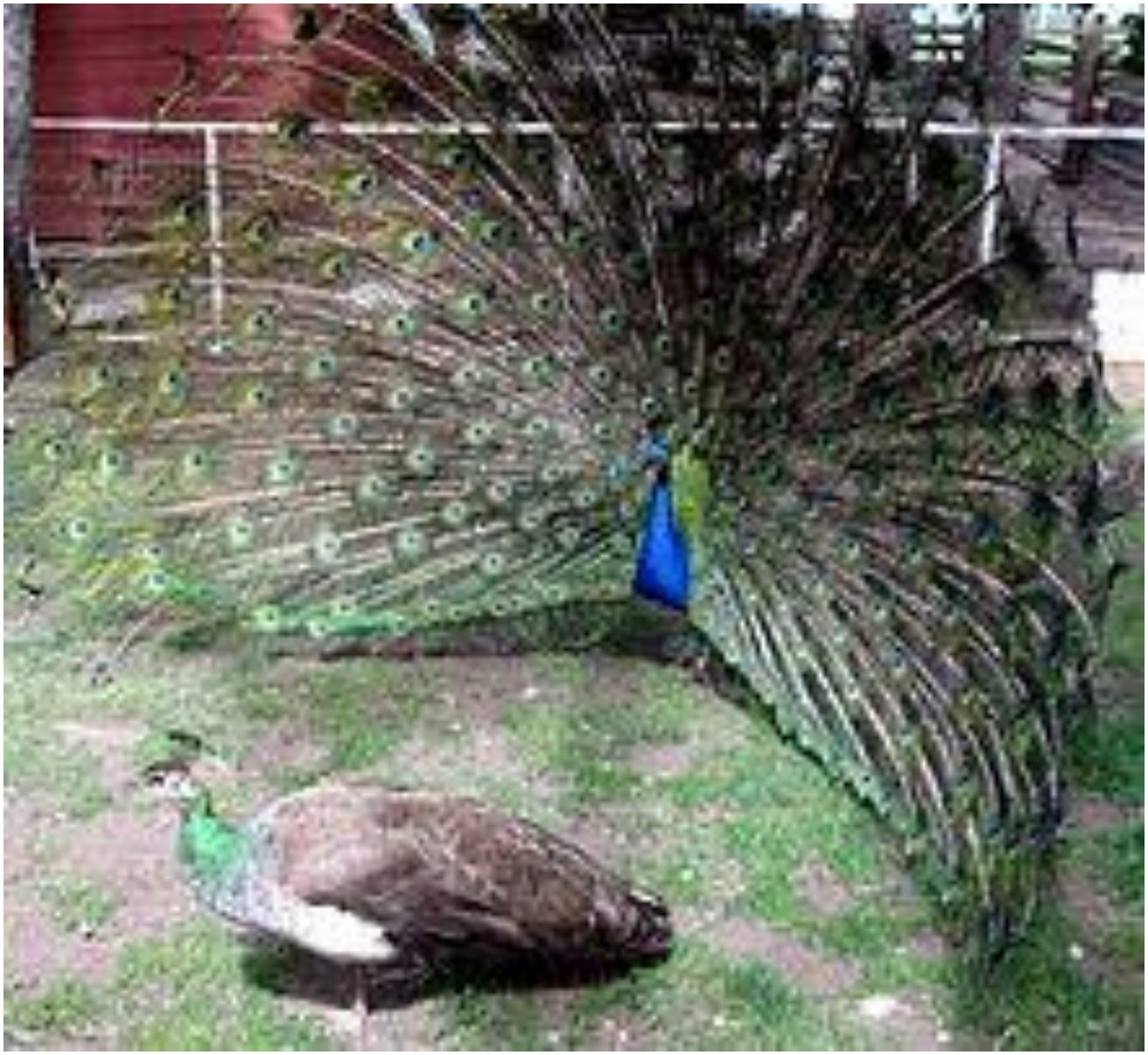

Photo is in public domain.

Peacock strutting with fully displayed tail feathers, trying to impress a peahen.

Darwin, of course, applied his ideas to humans as well

Image is in public domain.

Victorian cartoonists made fun of Darwin's ideas about sexual selection and the importance of visual displays.

In this cartoon, Darwin is inspecting the mimicking of steatopygia* in the new fashion for wearing bustles. The woman says to him, "Leave my emotions alone."

* Check meaning on Google. You will find info, photos, and many comments. It is interesting phenomenon that illustrates variety in human evolution.

Reproductive investment

2. Give an example of the extreme differences in reproductive investment of males and females of some species.

Reproductive investment

2. Give an example of the extreme differences in reproductive investment of males and females of some species.

- Stickleback fish: The male does all the nesting and care of the eggs.
- Other species of fish: In many, the male departs after fertilizing the eggs.
- Lions: Females invest more than two years, including gestation and nearly two years of care of the young. Males do comparatively little.
- Spotted sandpipers: Males do most of the brood-tending, while females desert the nest in order to lay another clutch of four eggs with a different male.

We will return to the sandpipers when we get to Q#12.

Reproductive output

3. Describe the very different ways in which an animal can maximize its reproductive output.

   The easiest way for males and females to maximize reproductive output is usually very different:

Reproductive output

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   The easiest way for males and females to maximize reproductive output is usually very different:

It is easiest for the **male** to increase number of offspring.

For the **female**, with limited egg production, it is better to try to maximize quality of offspring (including the choice of a father with "good genes" and with good resources to contribute).

The resulting mating systems amount to various **compromises between the interests of the male and the interests of the female**. Remember that the animals do not have to be aware of these interests.

-- Additional factor: reproductive investment, which is quite variable as just described.

-- This leads us to discuss mate choice, as well as the various mating systems.

4. **Mate choice by females** appears to be based, in general, on one of two properties of the males, or on both of these. What are they?
   - Give an example of how a female of a particular species bases her choice on one of these traits.
   - Give an example also of selection based on the other trait.

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   - Give an example also of selection based on the other trait.

1) Material benefits:

- **Resource provision** (p 169-172)
  - e.g., the male common tern brings freshly caught fish to the female.
  - *Cf.* the black-tipped hangingfly: a 20-minute rule! (*cf.* p 171: "5 minutes")
- **Other material benefit** (p 172-173), e.g., a male goldfinch (see slide 18) with more brightly colored plumage has more carotenoids in his body, indicating that he is a good forager & less likely to have parasites.

2) "Attractiveness" ***per se***:

(Problem: "runaway selection": What limits it?)

Described by RA. Fisher, major contributor to the foundation of Statistical Genetics, and more generally to the field of probability and statistics.

Limited by interference with ability to escape predators, or with ability to forage or feed or mate.

Female choice for resources in hangingflies

- *Bitticus apicalis* males present a "nuptial gift" of food to females.

- Females copulate for longer periods with males that present larger gifts.

- The longer she copulates, the more sperm he transfers.

Photo removed due to copyright restrictions.

Hangingflies:

Female choice: longer matings with males bearing bigger gifts

Photo removed due to copyright restrictions.

from R. Thornhill (1976)

Hangingflies:

from R. Thornhill (1976)

Photo removed due to copyright restrictions.

The payoff to the male is an increased quantity of sperm transferred

Hangingflies:

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If she finishes eating before 20 minutes, she flies off for another male (and meal).

If food is left after 20 minutes, the male gets a doggie bag.

American goldfinch, male and female

Courtesy of Chris Christner on Flickr. License CC BY-NC-SA.

Courtesy of **Mary** on Flickr. License CC BY-NC-SA.

The male's gift

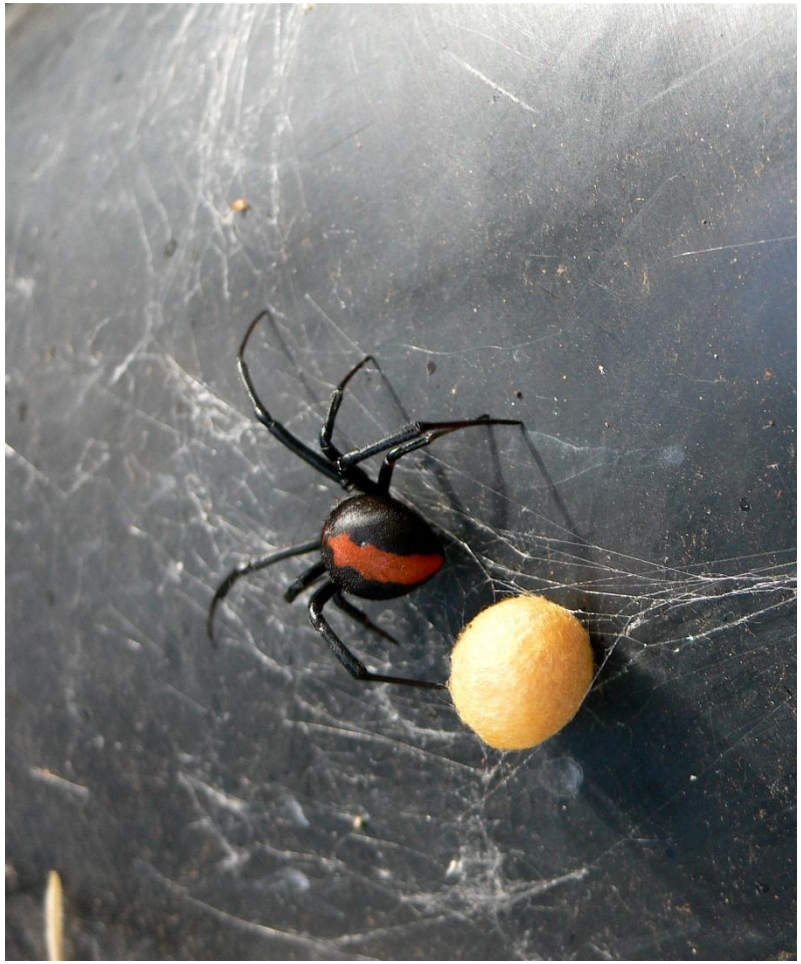
5. Evolution by natural selection is often summarized as evolution by "survival of the fittest". How is it, then, that in certain species of spiders (also in certain insects) the male is eaten by the female in the act of copulation?

   p 171 Australian red-backed spider: Two reasons why it can benefit the male in terms of his passing on his genes. ***What are those reasons?***

   Other species that do this:

   - Praying mantis.
   - The female tarantula (burrowing spider) also often eats males, not always its mate.

Australian red-backed spider



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p 171 Australian red-backed spider: Two reasons why it can benefit the male in terms of his passing on his genes. ***What are those reasons? (i.e., reasons why it has evolved)***

1) The male is not likely to survive long enough to find a second mate. (These spiders have short lives.)
2) A well-fed female is less likely to mate again, so the male that was eaten is more likely to pass on his genes.

Praying mantis

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mating

Female decapitated male

Praying mantis cannibalism

Sexual Cannibalism in the Praying Mantis *Hierodula Membranacea*

Authors: Birkhead, T.R.; Lee, K.E.; Young, P.

Source: Behaviour, Volume 106, Numbers 1-2, 1988 , pp. 112-118

- Well-fed females generally do not eat the male
- Females that are fed more are heavier and produce heavier eggs which are more likely to survive
- Females fed less are more likely to eat the male
- In an experiment, some females were prevented from eating the male, others were not. Those that ate the male produced heavier eggs—indicating that the cannibalism was adaptive for the female.
- Males try to avoid being eaten. It is probably less adaptive for the males.

-- thus, the interests of the female and the male, with regard to reproductive success, are different. This contrasts with the situation for the cannibalistic spiders.

Mate choice by males

6. What are the conditions that make it likely in a species that mate choice will be exercised by the males?

p 174 (box): In studies of female ornamentation, researchers have tended to focus on species with sex-role reversal. But there are exceptions where females are nevertheless brightly colored/ornamented.

What conditions could facilitate the evolution of selective mate choice by males?

Mate choice by males is less common, but it does occur in some species:

6. What are the conditions that make it likely in a species that mate choice will be exercised by the males?

p 174 (box): In studies of female ornamentation, researchers have tended to focus on species with sex-role reversal. But there are exceptions where females are brightly colored and ornamented. Example: the two-spotted goby—both sexes are ornamented. (See photo in Scott book) -- indicating sexual selection affecting both sexes.

Conditions that favor male choosiness:

- When males defend nest, there is a limit to the number of eggs/young he can defend. Therefore, a male cannot maximize reproduction just by indiscriminate mating.
- When there are more females than males, male choice is more likely – especially if the male is in charge of the nest, as in stickleback fish.

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Male mating strategies

7. Give an example of how in some species different individual males adopt very different mating strategies.

(although they have the same genes)

Scarab beetles, with and without horns

-- *see Box, p 177 and next slide.*

Other examples?

-- Small male toads

-- Small marine iguanas (a more unusual strategy)

Male mating strategies

7. Give an example of how in some species different individual males adopt very different mating strategies.

Scarab beetles, with and without horns -- *see Box, p 177.*

Two distinct morphologies have evolved in the males. The smaller ones have no horns and are more agile, often able to sneak past a large male into the female's tunnel and mate before the large male can go out, turn himself around, and re-enter the tunnel. (The "fittest" one is not always the successful one!)

Other examples?

-- **Small male toads**: They cannot croak loud enough to attract females, so they hide near a large toad, and sneak quick copulations when females approach.

-- **Small marine iguanas** have a more unusual strategy: Copulation requires several minutes for the male to ejaculate, but he has the ability to do this in advance and store the sperm in a penis groove. Thus he needs only a very brief copulation.

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Various mating systems

8. **Name and define** the different mating systems.

Why are there so many different ones?

How is the answer expressed by Nick Davies based on his studies of the reproductive behavior of the dunnock, a small European songbird (the hedge sparrow)?

(Note that all of the different mating systems have been seen in humans, some much more than others.)

p 179.

Davies et al:

- We should view the mating game not as a cooperation between the sexes but as a conflict resulting in a compromise in the interests of one or both of them (p 179-180).

Mating systems

- **Monogamy** (social; genetic)
- **Polygyny**: 1 male, >1 female
  - Resource based polygyny [females choose by value of territory]
    - Iguana, p 189-190
    - Pied flycatcher, p 190-192. Fig 8.9: "Polygyny threshold"
      - Female faced with choice between single male and a male that already has one female: It depends on territory quality.
  - Female defense polygyny
    - Seals, p 190
  - Lek-based polygyny (in about 200 species) *See Q13*
    - Great snipe p 193; certain fruit flies; various birds
- **Polyandry** *[Note: Polygyny and polyandry together are called polygamy]*
  - Sandpiper p 188 1 female, >1 male
- **Polygynandry**, as in the Dunnock, fig 8.3

This figure is worth studying, but there may be a mistake in lowest part of the figure.

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When monogamy is favored

9. Describe a situation that makes monogamy much more likely. Use an example with an explanation. p 181

When monogamy is favored

9. Describe a situation that makes monogamy much more likely. Use an example with an explanation.

Siberian hamster (Djungarian hamster, *Phodopus campbelii*):
Harsh conditions (very cold; limited food) make it unlikely the pups could survive without two caregivers.

Deep-sea angler fish: They are sit-and-wait predators. Encountering another angler fish is rare. When a pair does meet, the male attaches himself to the female as a parasite.

Mutually beneficial monogamy does occur in other species, but it is not as common as other mating strategies. In many cases, the male stays near the female after mating, in order to prevent other males from mating with her ("mate guarding").

Protecting fatherhood

10. The physical guarding of his mate by a male can greatly reduce the chances of extra-pair copulations. What methods, other than mate guarding, of preventing fertilization by another male have been found in some species? Describe two.

Preventing fertilization by another male:

- Crabs in which the male's ejaculate forms a "sperm plug" *(p 183)*
- Male dunnocks and "last sperm precedence" *(p 185-187)*; also, cloacal pecking by the male before copulation
- Sperm removal by male invertebrates (p 186)

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Sperm competition

11. Describe at least one means by which sperm competition could occur after mating.

In **polyandry** situations: In some species, last sperm precedence does not predict paternity. Sperm competition and female selection of sperm seems likely. (More on this later)

Male strategies?

p 187-188: Dragon lizard males, if they have seen their female with another male recently will mate longer, increasing the quantity of ejaculate.

Other possibilities?

Other means of sperm competition occurring after mating: male strategies

- Mate for a longer time period:
  - Produce more sperm, but also they occupy the female for a longer time period
- Produce more energetic sperm that can beat the competition

Sociobiologist have found much evidence on this.

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Serial polyandry in sandpipers

12. What has DNA analysis revealed about female sandpipers who desert a first clutch of eggs and find another mate with whom she lays more eggs?

p 188

Sandpipers:

- DNA analysis: The second clutch of eggs may have been fathered by the first mate and not the second.
- In such a case, she has stored sperm from the first mate, and delayed its use!
  - She has been able to make a covert choice.

Cf. Kangaroo, with a back-up fetus

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Males on display: the **lek**

13. What is a lek? How can a male in a lek who never succeeds in mating with a female nevertheless "benefit" by his participation?

Males on display: the **lek**

13. What is a lek? How can a male in a lek who never succeeds in mating with a female nevertheless "benefit" by his participation? *p 192-196*

- "Hot spot" model
- "Hot shot" model
- Female-preference model
- Kin-selection model (Preferred by Scott: see p 194-195)

(These models are not mutually exclusive.)

How is genetic variability maintained? It seems to be a recipe for loss of variation. Yet somehow, the females manage to maintain it (p 195-196).

She must mate with more than one male, although studies of leks do not reveal this.

9.20 Animal Behavior
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