|  |  |
| --- | --- |
| **Louse Case Study:**  **Part 2 – Reciprocal Natural Selection** | Wikimedia Commons |

## Objectives

Upon completion of this 3-part module, each student should be able to:

* Evaluate how an organism’s form and function is influenced by their genes, evolutionary history, interspecific interactions, and environmental selection pressures.

Upon completion of this week’s submodule, each student should be able to:

* Identify adaptations that help organisms accomplish the functions necessary for life.
* Analyze the evolutionary history of a group of organisms.
* Evaluate experimental evidence of reciprocal selection in a parasite and its host.

|  |
| --- |
| Owing to this struggle for life, any variation, however slight and from whatever cause proceeding, if it be in any degree profitable to an individual of any species, *in its infinitely complex relations to other organic beings* and to external nature, will tend to the preservation of that individual, and will generally be inherited by its offspring. The offspring, also, will thus have a better chance of surviving, for, of the many individuals of any species which are periodically born, but a small number can survive. I have called this principle, by which each slight variation, if useful, is preserved, by the term of ***Natural Selection***.  - Charles Darwin, On the Origin of Species, 1859 |

**Introduction**

In part 2 of the louse case study, we will be investigating the relationship between birds and their parasitic lice. Birds and lice both have adaptations that help them accomplish the functions necessary for life. These adaptations are coded for by genes and have been influenced by the evolutionary history of the organisms and the selection pressures acting on them. These selection pressures include the interspecific interactions that these groups participate in. When two species interact, they can exert selection pressures on each other. This relationship is called **coevolution**. In today’s laboratory activities, we will investigate the form and function of birds and their lice parasites and evaluate how the evolution of each organism is influenced by the other.

**Activity 1: Selection Pressures of Lice on Birds**

Natural selection is our second of two key forces that influence the form and function of an organism. Species that share an interspecific interaction with each other can cause reciprocal selection pressures on each other. This reciprocal selection is called **coevolution**. Today, we will investigate coevolution of birds and lice in a parasitic interspecific interaction by reviewing experimental and observational data.

**Citation:** Clayton DH, Lee PLM, Tompkins DM, Brodie ED. 1999. Reciprocal selection on Host-Parasite Phenotypes. The American Naturalist 154(3): 261-269.

Relationship between bill morphology and lice load

A close up of a map

Description automatically generated

Figure 1. Frequency distribution of lice on adult pigeons with normal and deformed bills.

1. Interpret the graph. What do these data tell you about the relationship between bill morphology and lice load?

Relationship betweenlice load and bird feather mass

A close up of a device

Description automatically generated

Figure 2. Mean mass of feathers from 58 high-load birds (solid bars) and 56 low load birds (striped bars). The value for each bird is the combined mass of the 10 longest feathers of a clump plucked from each body region: N = nape, BR = breast, S = side (under wings), K = adjacent to keel, B = back, F = flank, R = rump, V = ventral caudal tract. Wing and tail feathers were not sampled because they are not consumed by lice.

1. Interpret the graph. What do these data tell you about the relationship between lice load and feather mass?
2. How might feather mass influence the fitness of a bird?

Relationship between lice load and bird body mass

A screenshot of a cell phone

Description automatically generated

Figure 3. Mean body mass of birds with high lice load (solid circles) and low lice load (open circles) over the course of the study. Numbers above and below the error bars are sample sizes. Significant differences (p < 0.05) are indicated by an asterisk.

1. Interpret the graph. What do these data tell you about the relationship between lice load and bird body mass?
2. How might body mass relate to the fitness of a bird?

Relationship between lice load and bird survival

A picture containing text

Description automatically generated

Figure 4. Recapture rates of high- and low-load pigeons (p < 0.05 for high load pigeons).

1. Interpret the graph. What do these data tell you about the relationship between lice load and bird survival?

**Activity 2: Selection Pressures of Birds on Lice**

We have seen how lice exert a strong selection pressure on the fitness of birds. This selection pressure will favor any behavioral or morphological adaptation that allows birds to reduce their lice load. Now we will look at how those very bird adaptations exert a selection pressure on the form and function of their lice parasites. These “chewing” feather lice are ectoparasites that feed not on the blood of the birds, but on the downy part of their feathers. The main way that birds attempt to get rid of these parasites is by preening, in which birds use their bills to position feathers and clean plumage.

Relationship between bird preening and lice morphology

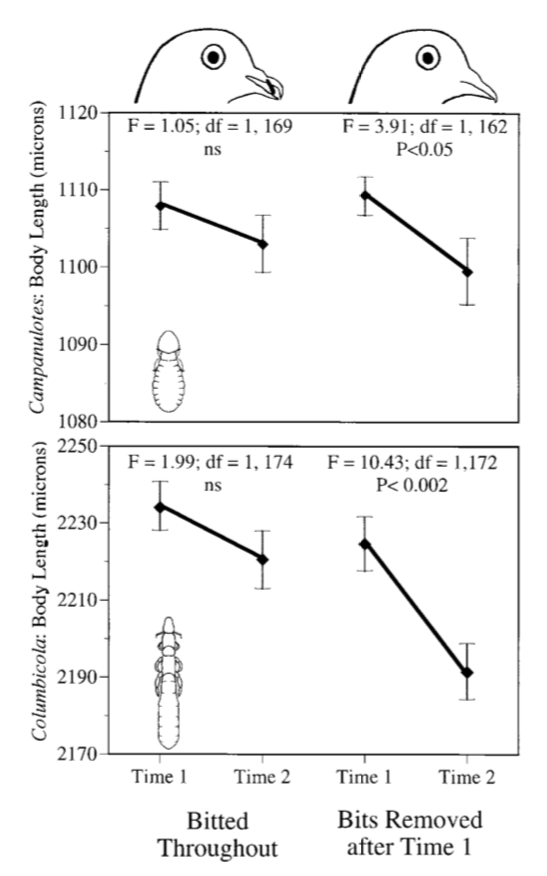


Figure 5. Effects of preening on morphology (body length) of two species of lice. Birds with bits in their bills are unable to preen.

1. Interpret the graph. What do these data tell you about the relationship between bird preening and lice morphology?

Selection Pressures and Ecomorphs

Figure 6. Nine lice species.

|  |  |  |
| --- | --- | --- |
|  |  |  |
|  |  |  |
|  |  |  |

1. Examine the specimens from nine different lice species in Figure 6 above. Given no information other than these images, propose a phylogeny (evolutionary history) for these 9 species. **Note:** You can either use drawing tools within your word processor to draw the phylogeny below or draw your phylogeny by hand on paper, take a picture, and insert it here.
2. Your proposed phylogeny is based only on the morphology of the nine species. We will be examining how the different lice morphologies relate to which part of a bird’s body each species is found. How might selection pressures be different for lice on different parts of a bird?

Lice on a single bird species can have up to 3 ecomorphs (a specific shape or “morph”, of an organism that evolves due to their ecological environment). Lice on different parts of the body have different ecomorphs that are adaptations for avoiding removal by preening. Avian wing lice are long and slender. This shape allows them to insert themselves between the barbs of the wing feathers to escape preening. Avian body lice have a characteristic short, rounded body and use a more active escape mechanism by burrowing in the downy portions of the feathers. Avian head lice have an intermediate body shape and escape preening by staying on the bird’s head, where the beak can’t reach. However, these lice have to watch out for the bird scratching at them with its claws.

1. Based on the descriptions above, sort the 9 lice from this activity into ecomorphs in the table below. The scientific names for each species are provided below and should also be entered into the table. Here’s a hint... there are three specimens of each ecomorph.
2. *Discocarpus cephalosus*
3. *Psittaconirmus neumanni*
4. *Psittoecus mollisoni*
5. *Forficuloecus greeni*
6. *Pseudophilopterus hirsutus*
7. *Anaticola crassicornis*
8. *Anatoecus keleri*
9. *Pseudolipeurus tinami*
10. *Campanulotes silvestris*

|  |  |  |
| --- | --- | --- |
| Letter | Scientific Name | Ecomorph |
|  |  | Head |
|  |  | Head |
|  |  | Head |
|  |  |  |
|  |  | Wing |
|  |  | Wing |
|  |  | Wing |
|  |  |  |
|  |  | Body |
|  |  | Body |
|  |  | Body |

1. Two of these three ecomorphs also often show cryptic coloration, or camouflage. Which ecomorph would you predict does not use camouflage to escape preening? Explain your prediction.

As we did with human lice, we will now use phylogenies to evaluate the evolutionary history of these species of bird lice. If each ecomorph evolved only once (homology) and then diversified into different species across bird types, we would expect all of the body lice species to be closely related to each other, all of the wing lice to be closely related, and all of the head lice to be closely related. An alternative hypothesis is that each ecomorph evolved multiple times in different louse lineages due to **convergent evolution**. In this case, we would expect louse species that parasitize the same bird species to be more closely related, regardless of ecomorph.

Below is a louse phylogeny based on three gene sequences. Find the genera represented in the table above on this phylogeny. If you are able to print out this page, circle or highlight the head lice in one color, wing lice in different color, and body lice in a third color. Or you could use your program’s drawing tools to do the same.

Figure 7. Lice genera by ecomorph and bird group. 

**Citation:** Johnson KP, Shreve SM, Smith VS. 2012. … microhabitat specialization in avian feather lice. BMC Biology 10:52

The figure below shows the lice genera identified by ecomorph and by the group of birds that each parasitizes.

Figure 8. Lice genera by ecomorph and bird group.



**Citation:** Johnson KP, Shreve SM, Smith VS. 2012. … microhabitat specialization in avian feather lice. BMC Biology 10:52

1. Based on comparison of the phylogeny in Figure 7 and the information in Figure 8, are the lice ecomorphs the result of homology or convergent evolution? Summarize your evidence.