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Session 5: Artificial Selection and response to selection

OVERVIEW

In many different types of species, ranging from insects to mammals, the male appearance is often characterised by exaggerated and conspicuous ornaments or colours. The degree of exaggeration is surprising given the costs of maintaining such traits though nutrient provisioning and the added risk of predation. One explanation is that female choice is responsible for driving forward the degree of exaggeration often seen in male sexual traits, although direct tests for the influence of female choice on the evolution of male traits are rare.

Today's data comes from an artificial selection experiment in the guppy (*Poecilia reticulata*), where the process of sexual selection was artificially recreated within the laboratory. In this species it has been shown that females prefer to mate with males which have larger patches of orange coloration on their bodies. Accordingly, in this study only males with above average orange levels were allowed to mate to a random female and contribute to the next generation. Today, we will use this design to understand how sexual selection and genetics interact to shape the evolution of male sexual traits.

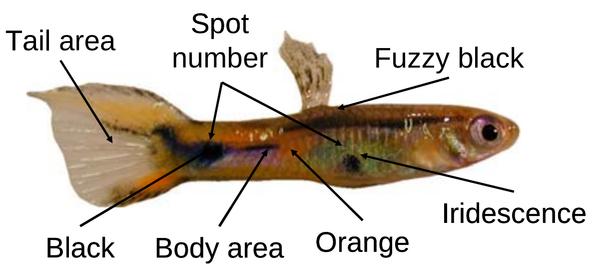


Figure 1: The colour patterns of the male guppy. The female preference for orange is thought to arise due to sensory exploitation, related to a food preference for small orange fruit that seasonally occur in Trinidad streams.

PART 1: PREDICTING THE THEORTICAL RESPONSE TO SELECTION AND CALCULATING THE ACTUAL RESPONSE

By selecting on a trait with a known intensity of selection and an estimate of the genetic variation in this trait we can first predict the theoretical response to selection based on the univariate breeders equation, where:

$$Response = h^2 S$$

(h^2 → Heritability; S → Selection)

In this example study, selecting on the top 25 percent males with the most orange for four generations resulted in an accumulated selection differential of 1.177 (the difference between mean and selection individuals over the four generations, in units of standard deviation). Based on a previous study from the same original population of guppies the heritability for orange was known to be 0.310 (e.g. 31 percent of the variance in orange is explained by additive genetic variance effects).

After four generations the change in orange coloration was then be measured and compared to both the original population estimates and to estimates for a control line where no selection was imposed.

Table 1: The selection line means and standard deviations for the average amount of a male's body that is coverage by orange in the original and treatment populations.

Orange body coverage (%)	Mean	S.D
Original Population	10.643	10.5
Selected lines	12.463	4.8
Control lines	12.321	4.0

QUESTION 1: Use the univariate breeder's equation and the mean and standard deviation of the original population to calculate the theoretical response to selection in orange.

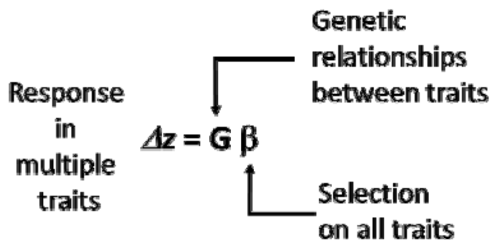
QUESTION 2: Calculate the actual response to selection for male orange colour. How does the response to selection differ if you use the original population or control lines as your reference point?

Question 3: How do the actual response to selection compare to the theoretically predicted response?

QUESTION 4: Do you think a lack of response to selection can be used to make inferences about the genetic basis of a trait? What can a lack of response tell you about a trait?

PART 1: UNDERSTANDING MULTIVARIATE GENETIC CONSTRAINTS AND CALCULATING THE ACTUAL RESPONSE

Although the intention of the guppy study was to select only on the orange colouration of males, the imposed selection acts on the entire male phenotype including the other colour patterns that are correlated with orange. To understand how the relationships with the colour patterns can change our understanding of the evolutionary potential for orange, we can use the multivariate version of the breeder's equation to explore how genetics and selection interact for multiple traits.



To calculate the response to selection in multiple traits, we can multiply the vector (a column) of the intensity of selection on all traits (in this case let's assume that selection was equal for all traits, although in reality selection will vary) by the matrix of genetic relationships amongst a sample of four colour traits.

Table 2: The genetic variance-covariance (G) matrix describing the genetic relationships amongst a sample of four colour traits.

G-matrix	Orange	Iridescent	Black	Tail
Orange	**0.310**			
Iridescent	-0.096	**0.201**		
Black	-0.098	0.062	**0.139**	
Tail area	-0.082	-0.049	0.014	**0.161**

QUESTION 5: Use the multivariate breeder's equation to calculate the response to selection in the four colour patter traits - first assuming there are no genetic covariances/correlations amongst the traits.

QUESTION 6: Now use the multivariate breeder's equation to calculate the response to selection in the four colour patter traits, but also include the genetic covariances.

QUESTION 7: Do you think that the covariances between traits could explain the lack of response observed in this study? In addition to those explored here, what other phenotypic or genetic aspects could contribute to the lack of response?