Quantitative characters

Joe Felsenstein

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A random-mating population with two genes having 2 alleles each, at equal frequencies, symmetrically affecting a quantitative character
The distribution of the genotypes and the quantitative character before artificial selection
An imaginary quantitative character with 4 loci

The character is a sum of effects including interaction and environmental effects:

\[
\begin{align*}
\text{starting value} & \quad \text{two loci that add up} \\
12 & + \\
\begin{array}{ccc}
\text{AA} & -1 & \\
\text{Aa} & 2 & + \\
\text{aa} & 3 & \\
\end{array} & \quad \\
\begin{array}{ccc}
\text{CC} & -2 & \\
\text{Cc} & 0 & \\
\text{cc} & 3 & \\
\end{array}
\end{align*}
\]

\[
\begin{array}{ccc}
\text{DD} & \text{Dd} & \text{dd} \\
\text{BB} & 5.24 & 0.8 & -4.0 \\
\text{+} & Bb & 3.28 & 0.1 & -3.08 \\
\text{bb} & 0.56 & -1.0 & -2.2 \\
\end{array}
\]

What kind of distribution will this lead to when gene frequencies at the four loci are \( p_A = 0.4 \), \( p_B = 0.5 \), \( p_C = 0.3 \), and \( p_D = 0.6 \)?
The resulting distribution

![Distribution Graph]

Phenotype

frequency

0 5 10 15 20 25 30 35
Distributions of quantitative characters

Fig. 6.2. Some unimodal distributions of sizes. Numbers of individuals. A, B, 1,000 male students; C, 1,519 Forficula; D, 80, 382, 530, and 205 guinea pigs in litters of 4, 3, 2 and 1 respectively; E, 1,584 + flowers of Iris virginica. (From data: A and B, Castle 1916a; C, Diakonov 1925; D, Wright and Eaton 1929; E, Anonymous 1926).
Fig. 3.49. Plasma concentration of isoniazid (INH) in 267 members of 53 families: bimodal distribution. The antimode is between 2–3 mg% (adapted from: Evans et al., 1960 [117])
Fig. 3.51. Distribution of enzyme activities for three GPT genotypes, almost combining to a somewhat skewed normal distribution (data from Becker, P.E. (ed.), 1976 [6])
Truncation selection

The distributions after artificial selection which saves only those individuals at or above 2

Before selection

frequency of A = 0.5

frequency of B = 0.5

After selection:

frequency of A = 14/22 = 0.6364

frequency of B = 14/22 = 0.6364

Mean phenotype of survivors = 2.545
In fact, the offspring will have this distribution:

(484 copies in all)

Mean phenotype of offspring = 2.545
Effect of truncation selection on one locus

With a larger number of loci, focusing just on one locus

phenotype
Effect of truncation selection on one locus

With a larger number of loci, focusing just on one locus

![Diagram showing phenotype distribution for different genotypes aa, Aa, and AA.](image-url)
Effect of truncation selection on one locus

The distribution of offspring at this locus

![Distribution of offspring at a locus](image)
### Effect of truncation selection with 5 loci - before

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| L---0-----1-----2-----3-----4-----5-----6-----7-----8-----9----10--- |
|------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                        | 2     | 11    | 49    | 115   | 176   | 268   | 212   | 119   | 36    | 11    | 1     |
Heritability

Heritability

(assuming genes are additive and environments are independent)

\[ V_T = V_A + V_D + V_E \]

Variance of a character = \( V_T \)

- Additive genetic variance
- Dominance variance
- Environmental variance

\[ h^2 = \frac{V_A}{V_T} \]

heritability in effect measures the fraction of variations that are passed on to the next generation,
Response to artificial selection

\[ R = h^2 S \]

\( h^2 \) = heritability

Quantitative characters – p.18/32
Response to artificial selection

Mean of selected individuals

Population mean

# of individuals

weight

If heritability = 0.4

S = selection differential

= mean of selected individuals – population mean = 100 lbs

R = gain

= $h^2 S = 40$ lbs
Some features of artificial selection experiments

- Replicate lines
- Relaxation of selection
- Reverse selection
- A selection limit?

Graph:
- Y-axis: Mean phenotype
- X-axis: Generations

Quantitative characters — p.20/32
Body weight in mice

Fig. 7.5. Courses of selection of mice for high or low weight at six weeks in comparison with controls. Effects are shown of late relaxation (dotted lines) in the high line and of reverse selection (broken lines) at two times in the low line. Standard deviations are shown below. Redrawn from Falconer (1955, fig. 1), © 1955 by Cold Spring Harbor Laboratory; used with permission.
Tooth decay in rats

Fig. 7.11. Average number of days from exposure of rats to a cariogenic diet to recognition of caries, under selection for resistance or for susceptibility. The crosses indicate the time after change to a less cariogenic diet. Reprinted, by permission, from Hunt, Hoppert and Rosen (1955). © 1955 by the American Association for the Advancement of Science.
White blood cell counts

Fig. 7.12. Courses of change of leukocyte counts, in mice selected for resistance or for susceptibility, over 11 generations. From Chai (1966).
Chicken legs

Fig. 7.15. Courses of selection (S) of White Leghorn fowls for increased shank length and suspension of selection (SS) in comparison with controls (P). Redrawn from Lerner (1958, fig. 4.10); used with permission.
Thorax bristles in Drosophila

Fig. 8.4. Courses of selection for number of abdominal chaetae in five lines of *D. melanogaster*, in each direction, followed by 19 generations of relaxation (left). Courses of selection (high and low) at different intensities (right). Redrawn from Clayton, Morris, and Robertson (1957, figs. 1 and 3).
Abdominal bristles in Drisophila

Figure 8.6. Courses of selection, high, H; low, L; in five lines each, for number of abdominal chaetae (sternital bristles) in females of *D. melanogaster*, continuing the selection of figure 8.4. The effects of relaxation are shown by broken lines. The courses in a number of unselected lines, *K*, are also shown. Redrawn from Clayton, Morris, and Robertson (1953).
Dobzhansky’s glass maze
Artificial selection on geotaxis

Fig. 8.10. Courses of selection in each direction for geotaxis in *D. pseudoobscura*. Mean scores of retests of 100 “best” flies (solid circles, minus; open circles, plus). Relaxation of selection, dotted lines. Reprinted, by permission, from Dobzhansky and Spassky (1969).
Artifical selection on phototaxis

Fig. 8.11. Courses of selection (solid triangles, minus; open triangles, plus) in each direction for phototaxis in *D. pseudoobscura*. Relaxation of selection, dotted lines. Reprinted, by permission, from Dobzhansky and Spassky (1969).
Long-Term Selection
A celebration of 100 generations of selection for oil and protein in maize

June 17-19, 2002
Holiday Inn Hotel and Conference Center
1001 West Kirby
Urbana, Illinois
USA
The Illinois corn selection experiment (oil content)

Figure 4.6 Results of a long-term experiment selecting for high and low oil content in corn seeds. Begun in 1896, the experiment has the longest duration of any on record and still continues at the University of Illinois. (After Dudley 1977.)
How it was done

This projection produced

- using the \texttt{prosper} style in \LaTeX, 
- using \LaTeX{} to make a \texttt{.dvi} file, 
- using \texttt{dvips} to turn this into a Postscript file, 
- using \texttt{ps2pdf} to make a PDF file, and 
- displaying the slides in Adobe Acrobat Reader.

Result: nice slides using freeware.