4. *Mathematics and Statistics*

SYMBOLS

4.1 All mathematical symbols consisting of single letters from the Latin alphabet should be italicized; the same is true for the vast majority of statistical symbols. Greek letters, however, should be in ordinary type. Multiple-letter terms may be italicized or not provided that the treatment is consistent:

$$z \quad s^2 \quad W_r \quad y = f(x) \quad t\text{-test}$$

$$\beta \quad L_{init}$$

$$CPUE_t \quad or \quad CPUE_t$$

Note that subscripts and superscripts are treated as separate symbols for this purpose; that is, a subscript or superscript consisting of a single letter should be italicized even if the main symbol is not, and conversely.

See Appendix A for the treatment of specific mathematical and statistical terms.

4.2 If punctuation follows a superscripted term, it should come after the superscript:

$$\ldots \text{ a higher value of } R^2, \text{ which implies } \ldots$$

LOGARITHMS

4.3 Logarithms are generally denoted by the abbreviation "log" with a subscript indicating the base (usually e or 10):

$$\log_e \quad \log_{10}$$

Note that e is italicized.

In the case of natural logarithms, however, "ln" may be used instead of "$\log_e$."

4.4 As a rule, there should be no space between the terms "$\log_e$" (or "ln") and "$\log_{10}$" and the variables and coefficients with which they appear:

$$1.23\log_e x$$

However, if the resulting expression is awkward, spaces, center dots, and parentheses may be used for clarity:

$$7.81 \log_e x \quad 7.81 \cdot \log_e x \quad 1.23 \log_e(\text{TL})$$

4.5   When the term "log" is used as a prefix, it is usually followed by a hyphen:

log-likelihood function   log-linear model   log-transformed data

but   lognormal(ity)   The data were log transformed.

However, nouns and adjectives involving "$\log_e$" (or "ln") and "$\log_{10}$" are not hyphenated:

$\log_{10}$ transformation $\log_e$ transformed data

VECTORS AND MATRICES

4.6   Vectors and matrices should be in bold type:

$$\mathbf{x} \quad \mathbf{U}$$

The operators in cross products (which are indicated by times signs and result in vectors) and dot products (which are indicated by center dots and result in single numbers [scalars]) should also be in bold type:

$$\mathbf{w \times y} \quad \mathbf{z \cdot x}$$

EQUATIONS

Formatting

4.7   The goal in formatting equations is to present them in a readily understandable way. Two guidelines that are useful in this regard are (1) to break lines before an operator, preferably a plus or minus sign and (2) to use spacing, parentheses and their equivalents, and (in the case of multiplicative terms) center dots or times signs to group terms logically:

$$\log_e(N_t+1) = \log_e(\alpha) + \log_e(N_t) \\ - \log_e[1 + (N_t/\gamma)]^\beta$$

4.8   Variable definitions may either be run into the text or presented in a list. There are two formatting options when they are run into the text:

$$dN/dt = rN \cdot [(K - N)/K],$$

where N is the population at any given time, r is the rate of population increase, and K is the carrying capacity of the environment.

or

where $N =$ the population at any given time, $r =$ the rate of population increase, and $K =$ the carrying capacity of the environment.

A list is preferable when there are numerous terms or they appear in more than one equation:

$$C = (M_r + M_a + \text{SDA}) + (F + U) + (G_s + G_r),$$

where

$C \ =$ the rate of energy consumption
$M_r =$ the standard metabolic rate
$M_a =$ the increase in metabolic rate due to activity
. . . .

Copyeditors should note that in the list (1) variable definitions should begin one em dash from the margin, (2) the equals signs should be aligned, and (3) any overflow should be hang-indented to the right of the equals sign.

4.9   In mathematical expressions, the sequence { [( )] } should be used for grouping terms:

$$t = [(x_1 - x_2) - D_0]/\{s[(1/n_1) + (1/n_2)]^{1/2}\}$$

(The reverse sequence is used in ordinary text.)

Text References

4.10   Numbered equations should be referred to in the text as follows:

equation (1)   equations (2) and (3)   equations (2)–(5)

When the reference itself appears within parentheses, the parentheses around the equation number should be omitted:

The most reliable estimates (from equation 7) . . .

STATISTICS

4.11   Simple summary statistics (means, ranges, and standard deviations [SDs] or errors [SEs]) may be reported in any of several ways:

(mean, 45.2 mm)   (mean = 45.2 mm)   *not*   (mean 45.2)

(mean, 45.2 mm; SD, 3.84)   *or*   (mean = 45.2 mm; SD = 3.84)
or   45.2 ± 3.84 (mean ± SD)

Whichever form is used must be used consistently, however. Avoid using expressions such as

The mean total length was 45.2 ± 3.84 mm.

because they are inaccurate (the mean was 45.2 mm, not 45.2 ± 3.84 mm).

Note that the term "coefficient of variation" must be defined as the percentage ratio of the standard deviation (or error) to the mean:

The coefficient of variation (100·SD/mean) was. . . .

4.12   The results of statistical tests should be reported by giving the test statistic (and, if it is not obvious, the type of test), the degrees of freedom, and the *P*-value in the following format:

. . . were significantly different (χ^2 = 13.91, df = 26, *P* < 0.001)

. . . were not different (ANOVA: *F* = 0.93; df = 4, 22; *P* = 0.46)

The degrees of freedom for *F*-statistics may also be presented as subscripts:

. . . (ANOVA: $F_{4, 22}$ = 0.93, *P* = 0.46)

Note that there should be a space after the comma separating the degrees of freedom for the numerator from the degrees of freedom for the denominator regardless of the number of digits.

4.13   As a rule, it is preferable to report individual *P*-values for all significant results. However, when a paper contains a large number of statistical results and distinguishing between the degrees of significance is not important, a general significance level may be reported instead:

Values were considered significant at α < 0.05.

P-values should not be given in abstracts or in conjunction with references to results in cited works:

Smith (1998) found a significant correlation between. . . .

4.14 The term "general linear model" encompasses several statistical methods, including linear regression, analysis of variance, and analysis of covariance, in which the errors are distributed normally.[2] For this reason, merely alluding to the general linear model does not provide an adequate description of the analyses performed. In particular, it is important to indicate (1) whether the analysis incorporates random as well as fixed effects and (2) whether the variables are continuous or categorical.

A fixed-effects analysis focuses on the particular factor levels or blocks included in the analysis (e.g., the relative abundance of fish in a particular set of streams, where stream is treated as a block), while controlling for other factors. By contrast, a "mixed" analysis includes both fixed and random effects by treating the blocks as being randomly selected from the set of all possible blocks (e.g., treating the sampled streams as a representative subsample of all the streams in the region of interest), again controlling for other factors.

A variable is said to be "continuous" when the data are ungrouped (e.g., fish weights), "categorical" when they are grouped (e.g., male vs. female or treated vs. untreated). An analysis with continuous variables gives insights into overall patterns (e.g., a regression trend); an analysis with categorical variables gives insights into differences among groups.

Note that some variables, such as fish age or year of sampling, may be treated as either continuous or categorical depending on the hypothesis in which one is interested, thus emphasizing the need to specify exactly how the general linear model was constructed. However the analysis is presented, the overall goal is to give readers enough information to replicate the procedure.

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[1] The Publications Department thanks Daniel Hayes for his contributions to this section.
[2] The general linear model is thus different from the general*ized* linear model, which can accommodate nonnormally distributed errors.