

5. Expansions of descriptive chromosomal indices.

Chromosomal indices such as arm ratio, centromeric index, and morphological index (Giannelli and Howlett, 1967) have been employed in routine chromosome identification and in the determination of unknown chromosomal anomalies for some time. Conflicting opinions in our laboratory, concerning the usefulness of such indices, prompted their examination.

Consider the following example to introduce the point in question: a chromosome with a long arm of 2.0 units and a short arm of 1.0 units has an arm ratio of 2.0. If the short arm is altered by 25% of its standard length, the resulting arm ratios become 1.60 (for an increment) and 2.66 (for a decrement). Compared to the original arm ratio of 2.0, an increment results in an absolute change of 0.40, a decrement in 0.66. That is, a decrement of the same length alters the arm ratio by a proportionally greater amount.

What is the mathematical relationship between an increment (Y) and a decrement (X)? If a specific chromosome arm is decreased by a proportion (x), what proportion of the arm must be added (y) to result in an arm ratio in which the absolute change for an increase and decrease are equal? Thus we want to know the value of (y) in terms of (x), $y = f(x)$.

Functions for (y) in terms of (x) were derived for each index. Two functions, one for a long arm change and one for a short arm change, were derived for each ratio. The six derived functions are listed below:

Arm Ratio:

$$\text{A.R.} = q/p$$

Short Arm:

$$y_p = x/1-2x$$

Long Arm:

$$y_q = x$$

Centromeric Index:

$$\text{C.I.} = p/(p+q)$$

Short Arm:

$$y_p = x(p+q)/(p+q-2px)$$

(1)

(2)

(3)

Long Arm:

$$y_q = -x(p+q)/(2qx-p-q) \quad (4)$$

Morphological Index:

$$M.I. = (p/q)*(p+q)$$

Short Arm:

$$y_p = (-(2p+q) \pm \sqrt{4p(p+q)+q^2+4px(2p+px+q)}) / 2p \quad (5)$$

Long Arm:

$$y_q = x(p+q)/(p+q-2px-2px) \quad (6)$$

where:

p = length of the short arm

q = length of the long arm

x = the proportion of an arm (decrement)

y = the proportion of an arm (increment)

Values of p, q and x, substituted in the positive root of equation (5) resulted in $y = x$; the negative root did not. Thus equations (2) and (5; '+' root) demonstrate that, for these examples, an addition and a deletion of a chromosome arm altered the arm ratio with the same absolute value; the remaining equations did not. Furthermore, values substituted for p, q and x demonstrated that function (1) was chromosome independent; the remaining functions (3, 4, 5; '-', 6) were all chromosome dependent, i.e., they are chromosome specific plots. Computer print out and plots have been obtained for each function $x = 0$ to 1.0, $y = 1.0$ to 0.

These functions demonstrate the inappropriateness of indices such as arm ratio, centromeric index and morphological index in a biometrical analysis designed to detect chromosomal differences. If, in a reciprocal translocation, both interchange segments involved long arms, arm ratio may be used; if both were in the short arms, then the morphological index may be used. Since an investigator may have no idea which type of chromosome alteration is present, the use of these indices becomes questionable. This argument applies only to a biometrical approach to anomaly detection and is based upon a mathematical approach. However, arguments for or against the use of indices should also have a statistical foundation. Thus, the actual validity of the functions may become a statistical problem. That is, the functions indicate that changes produced by segments

which add to or delete from the original length are not mathematically equivalent; however, we have not resolved their statistical equivalency to the present.

Giannelli, F. and R. M. Howlett 1967 Cytogenetics 6:420-435.
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6. Somatic association: the effects of various methods of arresting spindle-fiber development.

Driscoll and Darvey (1970), Avivi, Feldman and Bushuk (1969) and Back and Zang (1969) have suggested that the presence of somatic association of homologous chromosomes at metaphase is to some extent determined by the chemical treatment used to accumulate metaphase figures for the study.

Avivi, et al. using colchicine and cold treatment, noted in common wheat, Triticum aestivum L., that somatic association of homologous chromosomes detected at metaphase after using cold treatment was not observed when the experiment was repeated using colchicine instead of cold to arrest spindle-fiber development.

We have studied all possible homologous and non-homologous associations of chromosomes in a normal single-cross hybrid Seneca-60 using cold (5°C for 24 hrs.), 8-hydroxyquinoline (method of C.C. Chen, 1970), and monobromonaphthalene (method D. Weber as modified by J. Miles) to arrest spindle formation. For procedural and statistical considerations, see Horn and Walden (1970).

Fifty circular metaphase spreads in which the chromosomes were non-overlapping, well squashed and in the same focal plane were selected for each study. The results are presented in Table 1.