results emphasize the critical importance of the temporal factor in contour perception. In order to maintain the contour of the moving stimulus, each increase in $V$ of 1°/sec requires a corresponding increase in $T$ of from 20 to 30 msec.

The criterion of judgment required of the subjects eliminates apparent movement as the explanation of the data reported here. The stimulus during movement was always tilted slightly to the right (see Fig. 1), because of the nature of the apparatus. As long as this feature of the stimulus was reported, it was taken to indicate that real movement was being discriminated. It is believed, however, that the visual mechanism underlying apparent movement is involved to some extent in these observations, as it probably is in *all* forms of movement perception.

Further experiments dealing with the effects of numerous stimulus variables in relation to contour perception of moving stimuli are in progress.

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## Notes on the Ecology of West Indian Species of Malpighia

Interest in the West Indian or Barbados cherry (*Malpighia glabra* or *M. punicifolia*) becomes greater every year as the commercial use of this fruit increases. The discovery in 1946 of its unusually high vitamin-C content has led to the addition of its juice to other baby-food juices to fortify their vitamin content. Recent reports have shown that the fruit supplies thiamine, riboflavin, niacin, and vitamin A, besides calcium, iron, and some phosphorus. As a result, propagation and cultivation of the plant has reached unprecedented proportions in Puerto Rico. However, the incidence of nematodes in the soils of the northern coasts of Puerto Rico where cherry culture is well established has produced serious problems. Studies have been made of other species of the genus to determine their resistance to root knot and their compatibility as stock material on which to graft susceptible species.

Ledin stated that the West Indian cherry has been in Florida for more than 50 years, where it is called *M. glabra* (*1*). He further believes that it is the same plant that is called *M. punicifolia* in Puerto Rico or that the two may be different forms of the same species. Woodbury accepted two different cultivated species but is now willing to concede that there is confusion in the taxonomy of the group (*2*). The possibility that the cultivated material is of hybrid origin has also been suggested. Asenjo (*2*) finds no appreciable differences in the vitamin content of the taxa studied.

The taxonomy of the Caribbean species is highly confused. Studies now in progress by W. T. Stearn of the British Museum (Natural History) and N. Y. Sandwith of Kew, England, include the investigation of type and other classical specimens, most of which are in European herbaria. Pending the outcome of these basic studies, opinions of local botanists on the correct identity and names of these taxa seem to be purely conjectural.

Some species are more resistant to nematodes than others. Studies of graft compatibility between these species and cultivated material are in progress. Differences in stem size among plants of comparable age indicate that some species are unsuited as rootstock material. In this group are *M. linearis* and *M. coccigera*. In other instances, the abundance of deciduous stinging hairs reduces the desirability of otherwise potential understock species. This is especially true of *M. infestissima*, *M. shaferi*, and *M. fucata*.

*Malpighia* is a genus of some 30 species of shrubs and small trees of tropical and subtropical America, all of which are found in the native state in the West Indies. Cuba has some 20 wild species, six of which are endemic (*3*); Hispaniola has 15, which have been reported by Moscoso (*4*), but only five are endemic; Jamaica has eight with one endemic, as inferred from Fawcett and Rendle (*5*); and, in Puerto Rico, there are only six, two of which, and possibly a new one, are endemic. The distribution of these wild species is rather limited to the Greater Antilles. *Malpighia coccigera* extends as far south as Martinique and St. Lucia; *M. urens* reaches St. Vincent and Bequia of the Grenadines; and *M. linearis* reaches to Guadeloupe. Greater concentration seems to be northward and westward, especially on the larger bodies of land.

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## Statistical Estimation of the Size of a Small Population

The technique of estimation discussed in this report is restricted to the following methodological approach. A sample of one is drawn at random, tallied, marked for future identification, and replaced. As trials progress, individuals that had been marked are drawn with increasing frequency. These, of course, are replaced without being tallied, and eventually the process is terminated on the assumption that the population has been exhausted. Estimate of the size of the population thus depends on the criterion selected by the observer.

The criterion proposed here provides not only an estimate but also a statement of confidence regarding the estimate. The rational basis for this criterion and the computation procedure that it demands are illustrated in the following two examples. In the interest of clarity, the result of each drawing is shown graphically with a check in the appropriate square on cross-section paper. Consecutive drawings are numbered on the abscissa, and occurrences of unmarked individuals on the ordinate. Since the first drawing invariably yields an unmarked individual, the first result is always recorded as a check in the square adjoining the origin.

Figure 1*A* illustrates a hypothetical case in which every drawing yields the same individual. At the end of $r_1$ drawings the observer may terminate the sequence with a statement that the population consists of a single member. In making this decision, the observer rejects the alternative hypothesis of a population consisting of two members with only one of these appearing in every sample. The probability of this alternative, $p = (\frac{1}{2})^{r_1 - 1}$, may be equated to any desired decimal, and the value of $r_1$ may be computed. This value represents the minimal number of times that the same individual must be drawn if the probability of type-II error is to be no greater than the selected decimal (*1*).

In the present illustration the probability of rejecting the alternative hypothesis when true has been set at 10 percent. The equality, $(\frac{1}{2})^{r_1 - 1} = 0.10$, yields 4.3 as the value of $r_1$. Since the nearest larger integral value is 5, the conclusion is that there must be at least five consecutive drawings of the same individual be-

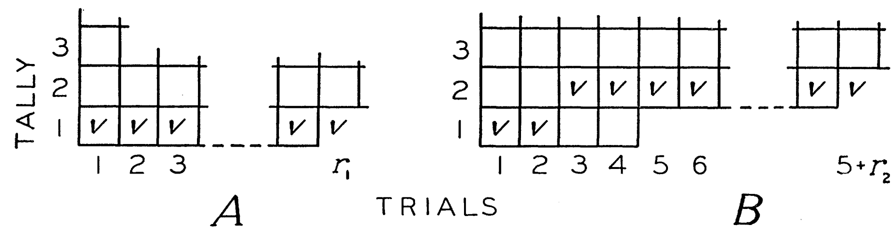


Fig. 1. Graphic representation of the results of sampling: (*A*) only one individual observed during sampling; (*B*) two individuals observed, the second occurring for the first time on the third trial.

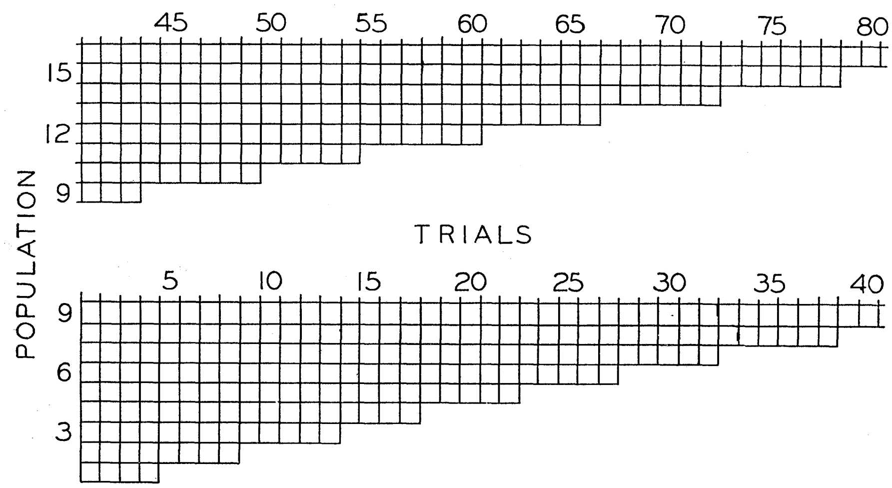


Fig. 2. Region that does not warrant acceptance of hypotheses regarding size of the population at 90-percent level of confidence. Any entry beyond the right boundary warrants such acceptance, with the estimate given by the ordinate at which the entry is made.

fore one may state with a 90-percent or higher degree of confidence that the population consists of a single member.

Figure 1*B* illustrates another hypothetical case in which unmarked individuals are observed on two of the first five drawings. In the diagram, observation of the second unmarked individual is located at the third trial, although, of course, the event may occur on any one of the four trials following the first. Should every individual drawn subsequently be found to have been marked, the observer is again confronted with the problem of ascertaining the minimal number of additional drawings that would permit him to state with 90-percent confidence that the population consists of only two members.

Assuming, for the moment, that the process is terminated after $r_2$ additional drawings, one considers the probability of type-II error in the rejection of an alternative hypothesis that the population is of size three. The error may be committed in either of the following ways: (i) by accepting, after five drawings, the hypothesis that the population is of size one, or (ii) by accepting after drawings of $5+r_2$ the hypothesis that the population is of size two. Calculation of the sum of probabilities of the two events may be facilitated by the Markov process, after the manner suggested by Feller (*2*):

$$^{N}p_{ab}{}^{(r)} = \binom{N-a}{N-b} \sum_{\nu=0}^{b-a} (-1)^{b-a-\nu} \binom{b-a}{\nu} \left(\frac{a+\nu}{N}\right)^{r} \qquad (1)$$

The symbol on the left reads as the probability of a change in state from $a$ to $b$ in $r$ trials, given $N$ states. In application to the present problem, it is the probability that a population of size $N$, $a$ of whom have been tallied and marked, will have a total of $b$ different members tallied and marked after $r$ additional drawings. Interpreted graphically, it is the probability of transition from $(x, a)$ to $(x+r, b)$.

The sum of the two probabilities is now written in this notation and equated to 0.10, thus,

$$^{3}p_{01}{}^{(5)} + {}^{3}p_{02}{}^{(5)} \cdot {}^{3}p_{22}{}^{(r_2)} = 0.10 \qquad (2)$$

The only unknown here is $r_2$, and solution of the equation yields $r_2 = 3.5$. This implies that the observer must have at least four consecutive drawings of marked individuals beyond the fifth observation if he is to state with 90-percent confidence that the population is of size two.

By following the procedure illustrated in these two examples one may establish terminal points for higher values on the vertical axis. The calculations become somewhat complex, but the basic approach remains the same. Figure 2 shows the terminal boundary that I computed for 90-percent confidence which is adequate for a population not exceeding 15 members. Current work includes extension of the boundary for higher values of the population and construction of boundaries for other levels of confidence.

Problems in research to which the criterion is applicable arise frequently, one of the most pertinent being the enumeration of wild-life specimens in a circumscribed area. Another example is one in which size of the population has no importance of itself, except insofar as the experimenter wishes to test every available member in order to increase the statistical significance of his results. The method is also being examined for potentialities of application to research in psychology. One promising possibility is that of a criterion of mastery in conditioning, based on my premise that a conditioned response depends on recurrence of one of a finite number of specific vigilance reactions (*3*).


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**References and Notes**

1. Since the power of the test increases for alternative hypotheses of populations exceeding two members, such hypotheses are rejected without violating the criterion selected on the basis of the alternative of only two members.
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13 June 1956


## Enzymatic Reduction of Disulfide Bonds in Cell Wall Protein of Baker's Yeast

The presence of a pseudokeratin-type protein, which contains 2.1 percent sulfur, has been demonstrated in isolated, clean cell walls of baker's yeast (*1*). The protein was solubilized and found to be firmly attached to a mannan component of the cell wall. Physical studies on this mannan-protein, which constitutes a major structural component of the yeast cell wall, indicate that it is monodisperse. It can now be reported that enzymatic reduction of disulfide linkages in the protein has been achieved by the use of cell-free particulate preparations from baker's yeast (*2*).

Portions of pound cakes of baker's yeast (Anheuser Busch, *3*), suspended in 8.5-percent (weight per volume) sucrose solution containing 5 percent (volume