

TONGUE-FOLDING AND TONGUE-ROLLING

In a Sample of the Chinese Population

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STURTEVANT⁴ found that there exist two fairly distinct classes with respect to the ability to turn up the lateral edges of the tongue. In his opinion this ability is possibly due to a single dominant gene. Recently, Urbanowski and Wilson⁵ also reached the same conclusion. Apart from the rolling up of the tongue edges, another character of tongue movement, the upfolding of the tongue tip, has been noted by Hsu¹ and reported in a separate paper. According to his finding, this character is certainly caused by a single Mendelian factor, the individuals with the ability of tongue-upfolding being homozygous for the recessive gene. The purpose of this paper is to report the results of population studies of these two characters in populations and to investigate the relation between these two pairs of genes.

Material

The survey was carried out at Chekiang University and the University Middle School, Hangchow, China. The abilities of tongue-folding and tongue-rolling were tested simultaneously. The subjects examined at Chekiang University were freshmen whilst in the University Middle School, all the students were included. The data here collected inevitably involve some errors in regard to the ability of tongue-folding. One source of error is the psychological effect, since these tests were made in the course of physical examinations wherein the students' fear of discovery of physical defects may have affected the tongue rolling and folding abilities. The other difficulty is in the tongue-folding trick itself. As reported by Hsu, though the majority of the persons who possess the abil-

ity of tongue-folding can do this trick instantly without previous practice, in a few persons it is acquired only by practice. During the course of testing, the latter are erroneously included in the inability class. Naturally these errors may, more or less, obscure the data, but the effect seems very slight and may be neglected.

Results

Table I shows the total data we obtained. The sexes are recorded separately and the subjects are also classified according to geographical origin. In this table, the symbol r represents the tongue-rolling ability, and f , the tongue-folding ability. The plus sign (+) indicates the persons who can do the respective trick and the minus sign (—), the persons who cannot do that trick. (We will use these same symbols throughout the paper.)

Table II shows that although the proportion of persons who can roll but not fold the tongue is similar in the two sexes, there is a sex difference in the ability to both roll and fold the tongue in favor of women.

From Tables I and II one may note the interesting fact that no people who can fold up but not roll the tongue have been discovered. Whether this absence is due to chance or other cause needs further study. If $A-a$ is a pair of genes responsible for tongue rolling, the genotype of people who can roll is either AA or Aa , and of people who cannot do it is aa . If $B-b$ is another pair of genes responsible for the tongue folding, the people who possess this ability are bb , while the people incapable of doing it are either BB or Bb . Then the genotype $A-bb$ can do both the tricks. $A-B-$ can

roll the tongue, *aabb* can fold up the tongue, and *aaB-* cannot do either. Now, assuming a random combination of these two pairs of genes, we should obtain the results as shown in Table III.

From Table III, the expected number in class *aabb*, that is, the people who can fold up but not roll the tongue, is 12.85, but the observed number is zero, χ^2 is 21.35, and the probability is less than 0.01. Thus it is obvious that the absence of the *aabb* class is not due to chance, but is caused by other factors.

The linkage between these two pairs of genes might be the cause. But Hsu and Liu² have pointed out that in a random sample of a population, when the equilibrium state has been reached, neither linkage nor independent assortment would interfere with the random combination of the related genes.

In view of this fact the authors must offer a new explanation. Assuming that *A* and *B* are complementary, the expression of *b* must depend on the presence of *A*, otherwise the *b* effect cannot be expressed.

If this is the case, the first thing we could do is to find out the proportion

of persons who are homozygous for the recessive tongue folding gene among the phenotypical negatives, and compare the expected number with the observed numbers so as to see whether the explanation is probable.

If *x* is the proportion of persons homozygous for *aabb* among the phenotypical negatives, then

$$34:615 = x:(394-x), \text{ and} \\ x = 20.64$$

This means that among the phenotypical negatives, 20.64 individuals should have the genotype *aabb*. From the above calculations we could obtain the frequencies of the two tongue-movement characters separately (Table IV).

Since the interaction of the two pairs of genes is clear, then the gene frequencies both for tongue-rolling and tongue-folding can be obtained easily (Table V). The frequency of *A* is 0.39. and of *b* is 0.23.

Discussion and Conclusions

Examples of complementary factors in animals and plants are not rare, such as flower color in the common yellow daisy and coat colors in rodents. In human

TABLE I. Geographical distribution of tongue rolling and tongue upfolding characters.

Province	Can Roll and Fold <i>r+</i> <i>f+</i>			Can Roll but Not Fold <i>r+</i> <i>f-</i>			Can Neither Roll nor Fold* <i>r-</i> <i>f-</i>			Total		Grand Total
	Actual No.	%		Actual No.	%		Actual No.	%		♀	♂	
Anwhel	0	0	0.00	12	17	60.42	9	10	39.58	21	27	48
Chekliang	8	8	2.77	82	255	58.41	36	188	38.82	126	451	577
Kiangsu	1	3	2.41	36	62	59.04	16	48	38.55	53	113	166
Other provinces (16)	9	5	5.56	70	81	59.92	35	52	34.52	114	138	252
Total:	18	16	3.26	200	415	58.96	96	298	37.78	314	729	1,043

*No persons who could fold but not roll the tongue were found.

TABLE II. Frequency of two tongue movement characters in relation to sex.

Sex	Can Roll and Fold <i>r+</i> <i>f+</i>		Can Roll but Not Fold <i>r+</i> <i>f-</i>		Can Neither Roll nor Fold <i>r-</i> <i>f-</i>		Total
	Actual No.	%	Actual No.	%	Actual No.	%	
♀	18	5.73	200	63.70	96	30.57	314
♂	16	2.19	415	56.93	298	40.88	729
Total	34	3.26	615	58.96	394	37.78	1,043

TABLE III. Test for independence of two tongue movement characters.

Genotypes	<i>A-B-</i>	<i>A-bb</i>	<i>aabb</i>
Phenotypes	<i>r+</i> <i>f-</i>	<i>r+</i> <i>f+</i>	<i>r-</i> <i>f+</i>
Observed	615	34	0
Expected	627.80	21.15	12.85

$$\chi^2 = 21.35; P < 0.01$$

TABLE IV. Proportions of tongue rolling and tongue folding characters.

Phenotype	Rolling		Folding	
	<i>+</i>	<i>-</i>	<i>+</i>	<i>-</i>
Genotype	<i>AA+Aa</i>	<i>aa</i>	<i>bb</i>	<i>BB+Bb</i>
Actual no.	649	394	34.00	615.00
%	62.22	37.78	5.24	94.76

TABLE V. Gene frequencies.

Rolling		Folding	
<i>A</i>	<i>a</i>	<i>B</i>	<i>b</i>
0.39	√.3778	0.77	√.0524
	0.61		0.23

beings only one possible case has been reported by Snyder³ where deaf-mutism appears to depend on one combination of two factors.

The tongue genes *A* and *b* act on different characters, and the former gene can produce the character in heterozygous condition, while the latter gene can produce the character only in the homozygous recessive condition. Furthermore, the development of the folding character depends on the presence of the dominant condition *A*.

As to the cause of the relationship between these two characters, it is probably due to the structure of the tongue muscle. Folding up the tongue tip is a rather delicate trick which requires

the movement of many muscles simultaneously. The rolling process is simpler, as compared with the folding process. In those persons who can fold up the tongue tip, the structure of the tongue muscle can also meet the requirements of the rolling process.

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HERITABLE CHARACTERS IN MAIZE

Linkage of a Factor for Shrunken Endosperm with the *a*₁ Factor for Aleurone Color*

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IN 1942, an open-pollinated plant of maize having colorless aleurones and liguled leaves was crossed with a plant of an inbred line (*LA*) having colorless aleurones and liguleless leaves for the purpose of obtaining material to demonstrate the inheritance of liguleless. The pistillate parent was from commercial seed of unknown ancestry. The staminate parent was from seed which was 12 years old. The germination was poor but enough plants were obtained for the purposes of pollination. In addition to being homozygous for liguleless, line *LA* carried the factors for aleurone color, *aaCCRRPrPr*. The ear resulting from the cross had purple kernels indicating that the pistillate parent carried aleurone factors *AA*. Results obtained

in following generations indicate that the pistillate parent had *pr* and either *c* or *r* or probably both as homozygous recessives.

In 1943, 19 self-pollinated ears were obtained which showed multi-factor segregation for aleurone color. Among the kernels with colorless aleurones were a number which were shrunken. No colored† kernel showed the shrunken condition. Hutchison^{2,3} and others have shown that a factor for shrunken endosperm (designated *sh*) is closely linked with the factor *c* for aleurone color. As can be seen by comparing Figure 9A-C with Hutchison's figures, there is considerable resemblance between his "shrunken" and ours. It was assumed that the factors involved in the above cross were

*Paper from the Herbarium and the Botany Department of the University of Michigan. Facilities for growing the lines of maize were furnished by the Botanical Gardens. The writer is indebted to L. F. Randolph for supplying tester lines for use in this study and to M. M. Rhoades for reading and criticizing the manuscript.

†Since *Pr* only modifies the expression of color and is not important in this study, red and purple aleurones are classified together as colored.