

Skeletal polymorphism and genetic drift in a Delhi frog, *Rana cyanophlictis* – a follow-up study

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SUMMARY

Four isolated populations of the skipper frog, *Rana cyanophlictis* were first studied in 1965 and then again in 1975. The genetical changes were measured by the incidence of 19 non-metrical skeletal variants. It was found that these populations have changed very little in 10 years, although the inter-population diversity, as judged by the estimates of divergence, is less now than previously. This could be due to the similar environmental conditions prevailing in Delhi and its neighbourhood from where these frog populations were collected.

INTRODUCTION

In an earlier study Grewal & Dasgupta (1967) described the skeletal polymorphism and genetic drift in populations of a frog, *Rana cyanophlictis*, from Delhi. Nineteen discontinuous skeletal variants were used to analyse the diversity among five different populations of skipper frog.

In the present study the genetical compositions of the same populations of frogs have been examined again after a period of 10 years by studying new samples of animals collected from the original sites. The same 19 skeletal variants are used to analyse the diversity between the populations.

MATERIAL AND METHODS

The frogs were collected from the ponds described in the previous paper. However, the method of collection was different and this time they were caught using a fishing net instead of a fishing rod. Also, the present study does not include frogs from the original population *D*, as the site of collection has now been levelled and used for building purposes. In both the studies only adult specimens of both sexes were used. Their skeletons were prepared by the papain maceration technique. The 19 skeletal variants classified have already been described in detail in the original paper.

RESULTS AND ANALYSIS

The percentage incidence of 19 skeletal characters from both studies are given in Table 1. For bilateral characters each side of the animal is considered as a separate entity. In certain cases where the specimen was damaged or partly lost, the percentages are based on a lower total than that recorded for the population. In both studies all the skeletons were scored by the present author. As there was no significant difference between males and females their percentages were pooled.

Table 1. *Percentage frequency of 19 skeletal variants in four populations of Delhi frogs examined in 1965 and 1975*

	Number of animals							
	A		B		C		E	
	1965	1975	1965	1975	1965	1975	1965	1975
Males ...	50	31	26	45	0	48	46	34
Females ...	50	46	46	50	20	27	50	50
Variant								
(1) Accessory ophthalmic foramen	22.0	19.7	15.4	10.8	10.0	36.0	12.4	10.1
(2) Anterior surface of fronto-parietal serrated	57.0	57.2	55.6	50.0	90.0	59.3	40.0	45.2
(3) Fused fronto-parietals	17.0	17.1	21.1	16.0	0.0	25.3	16.7	12.1
(4) Fronto-parietal foramen	13.5	14.5	12.5	9.8	7.5	6.2	10.2	9.0
(5) Imperfect fronto-parietal foramen	20.5	19.1	22.0	20.5	20.0	22.6	18.5	23.8
(6) Oculo-motor foramen double	15.0	13.2	4.2	3.3	0.0	9.3	4.1	3.6
(7) Additional maxillary foramen	45.0	46.0	42.0	41.9	82.5	40.7	31.8	38.7
(8) Dyssymphysis of atlas	1.0	6.5	5.6	5.3	50.0	50.7	11.5	14.3
(9) Absence of notch on anterior surface of atlas	16.0	18.7	17.0	17.4	5.0	5.3	18.8	17.1
(10) Dyssymphysis of Th-I	0.0	1.3	2.8	0.0	0.0	0.0	0.0	1.2
(11) Rib-arch of Th-II	75.5	75.8	69.5	74.7	39.5	61.3	62.5	55.4
(12) Rib-arch foramen of Th-II	48.5	50.3	66.0	63.4	77.5	58.7	50.5	48.8
(13) Serrations on transverse processes	37.0	39.0	7.0	10.5	0.0	16.0	7.5	6.0
(14) Exchange of ribs	5.0	1.3	1.4	2.2	5.0	1.3	2.1	1.2
(15) Sacralization of Th-VII	0.0	0.0	0.0	1.1	0.0	0.0	0.0	1.2
(16) Procelous centrum of Th-VII & sacral	7.0	4.0	11.1	7.5	0.0	0.0	6.3	7.1
(17) Partial procelous centrum of Th-VII and sacral	1.0	2.6	2.8	6.5	0.0	1.3	2.1	4.7
(18) Vertebral fusions	9.0	7.8	5.6	8.6	5.0	4.0	3.2	9.5
(19) Perforated urostyle	12.0	15.3	14.0	16.8	10.0	14.0	6.3	7.1

Measures of the degree of divergence of the populations were obtained using the method of Grewal (1962). Later, Berry (1969) adopted Professor C. A. B. Smith's suggestion that the square root of the measure of divergence (estimate of divergence) be taken thereby ensuring that the distance between populations 1 and 3 is not greater than the sum of the distances between populations 1 and

2, and 2 and 3; this modification has been used extensively since then. The calculations are as follows:

$$\text{Measure of divergence} = (\theta_1 - \theta_2)^2 - (1/n_1 + 1/n_2),$$

where θ_1 and θ_2 are the angular transformations in radians of the percentage frequencies of any character in two populations (1, 2) of sizes n_1 and n_2 . An approximate estimate of the standard error (s.e.) of the mean measure of divergence is:

$$\text{s.e.} = \sqrt{\frac{4 \cdot \text{mean measure of divergence} \cdot (1/n_1 + 1/n_2)}{\text{number of characters}}}$$

$$\text{Estimate of divergence} = \sqrt{\text{mean measure of divergence}}$$

$$\text{with standard error} = \frac{\text{s.e. of mean measure of divergence}}{2 \cdot \text{estimate of divergence}}$$

$$= \sqrt{[(1/n_1 + 1/n_2) (1/\text{no. of characters})]}.$$

This standard error is calculated on the assumption that the mean measure of divergence is appreciably greater than zero, i.e. it is not the standard error on the null hypothesis of no divergence.

Table 2. Mean estimates of divergence

Between the 1965 and 1975 samples from four populations, *A*, *B*, *C* and *E* (in italics), and between pairs of populations for each of these years including population *D* for 1965 (in roman). (Approximations of the standard errors of the estimates of divergence in parentheses. Note: a negative value for the mean measure of divergence indicates that there is no appreciable difference between the samples compared.)

	<i>A</i>		<i>B</i>		<i>C</i>		<i>E</i>		<i>D</i>
	1965	1975	1965	1975	1965	1975	1965	1975	1965
<i>A</i>	-0.100		0.205	0.167	0.592	0.305	0.239	0.232	0.541
			(0.037)	(0.036)	(0.057)	(0.038)	(0.034)	(0.037)	(0.038)
<i>B</i>			-0.138		0.468	0.333	0.077	0.100	0.431
					(0.058)	(0.036)	(0.039)	(0.035)	(0.041)
<i>C</i>					0.414		0.482	0.295	0.327
					(0.058)		(0.056)	(0.036)	(0.060)
<i>E</i>							-0.063		0.367
									(0.038)

The 1965 measures of divergence have therefore been converted to estimates of divergence (with their revised standard errors) and compared with the new data from 1975 (Table 2) derived from the values given in Table 1. Population *D* for 1965 has been added to this table for the sake of completeness. For a discussion of the different methods of calculating genetic distance see Smith (1977) and for the use of measures and estimates of divergence, see Sjøvold (1973).

The frequencies of the 19 variants studied in 1965 and 1975 have not changed appreciably in populations *A*, *B* and *E* (Table 2, negative values in italics). How-

ever, population *C* has changed markedly in these years (Table 2, in italics). There are a number of factors which may have caused this difference. For eight of the skeletal variants there has been a marked change in their frequency. Characters 3, 6 and 13 are now present where previously they were absent; characters 1 and 11 have both increased in frequency, while 2, 7 and 12 have decreased. Apart from variant 1 these changes have made population *C* more like the other populations. But there are still certain variants (notably 8 and 9) which are peculiar to it. The small size of the sample in 1965 (20 animals) may be pertinent.

In 1965 there was no appreciable difference between populations *B* and *E* (Table 2) and they are still very similar in 1975. Population *A* still differs from *B* and *E*, although to a slightly lesser extent than in 1965, while population *C* remains markedly different from the other three populations.

DISCUSSION

Analysis of the new data from the four collection sites shows that populations *A*, *B* and *E* have not altered appreciably from 1965. These frogs all come from large perennial bodies of water and one is, therefore, probably sampling large permanent populations which are fully adapted to the prevailing environmental conditions. Population *C*, on the other hand, comes from a small annual pond which dries up in the summer and is recolonized each year by migratory frogs from nearby areas. As the skipper frog is completely aquatic it can only migrate via puddles during the rainy season (July–August). The founding population may, therefore, be different each year and there is no way of knowing the origin of these animals. It is unlikely that they could come from either populations *A* or *B* as both are over 4 km from *C* and the areas between them are built-up. Population *E* is even further away.

Populations *A*, *B* and *E* are all probably 'large' populations as they show no signs of random genetic drift. The change in population *C* is probably due to random drift through being founded by individuals from populations like *A*, *B* or *E*, but it could also be due to the fact that the environment of *C* changes radically each year. This pond dries up whereas the others do not.

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