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Altitudinal Cline in the Body Size of the Japanese Common Toad (Amphibia, Bufonidae) from Toyama Prefecture, Central Japan*

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富山県産アズマヒキガエルの体長と高度の関係

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富山県内の12地点(標高50m～2,040m)から得られたアズマヒキガエル *Bufo japonicus formosus* の体長には，高度と関係したクラインがあることが認められた。成体の雌雄ともにその体長は分布域の高度と負の相関を示し，相関関係に雌雄差は認められなかった。高度に関係したクラインの意義をヒキガエルの分類と関連させて論じた。

Abstract: Presence of altitudinal cline in snout-vent length (SVL) of the Japanese common toad, *Bufo japonicus formosus* BOULENGER, from various localities of Toyama Prefecture was demonstrated. Each sex showed a significantly negative correlation between altitude and SVL, and no sexual difference in the regression lines was found. Significance of altitudinal cline was discussed in relation to classification of the Japanese common toad.

Toyama Science Museum has hitherto secured a number of toad specimens, collected mainly within Toyama Prefecture. The Japanese stream toad (*Bufo torrenticola* M. MATSUI) has so far been recorded only from montane regions of Toyama Prefecture (NAMBU, 1980), while the Japanese common toad has been found from almost everywhere in Toyama Prefecture. Since Toyama Prefecture is bordered by the Japan Sea on the north and by high mountains reaching 3,000 m in altitude on the south and east, the habitat of the common toad lies from nealy sea level to the top of high mountains. This altitudinal range is remarkably wide in comparison with relatively narrow latitudinal and longitudinal ranges of Toyama Prefecture. Such geographic conditions seem to offer us a good opportunity to analyze the relationship between altitude of the habitat and body size in the common toad.

*Contributions from the Toyama Science Museum No.37

Material and Methods

Adult common toads, *B. j. formosus* BOULENGER, identified by the relative size of the tympanum according to MATSUI (1984), were collected from 12 localities ranging in altitude from 50 m to 2,040 m (Fig. 1), during 1978 and 1983. On Tengudaira (about 2,300 m) near the point 11, young individuals of *B. j. formosus* were observed but no adults were observed. This is the highest habitat of the common toad in Toyama Prefecture. Thirty adult male and 12 adult female specimens were examined in the present study. Sex and maturity were determined after MATSUI (1984). Most specimens were first fixed in 10% formalin and later transferred and stored in 70% ethanol. Snout-vent length (SVL) was measured with a dial caliper to the nearest 0.1 mm. For each individual, the altitude of the sampling point (X m) in relation to the SVL (Ymm) was plotted on a graph and their relationship was examined by the regression statistics (SOKAL and ROHLF, 1981).

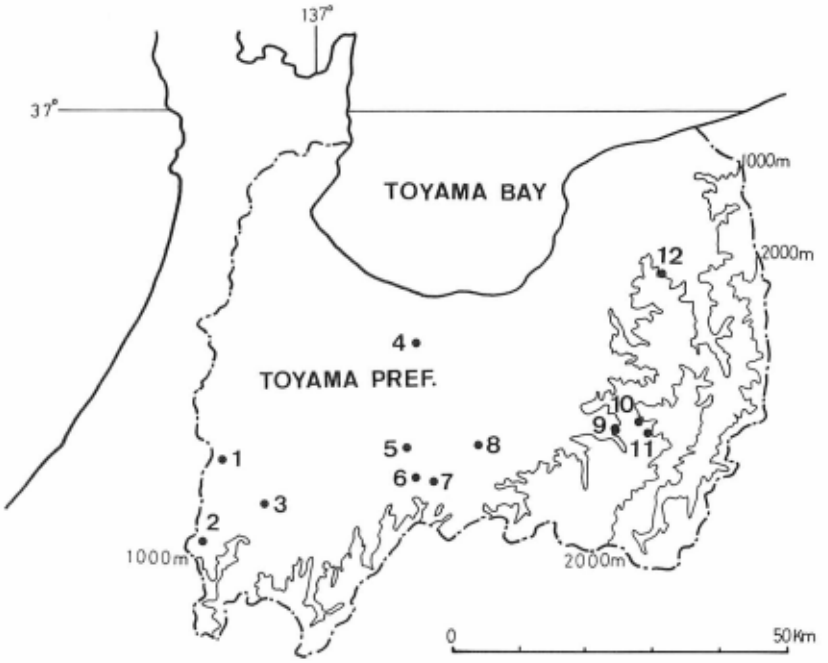


Fig. 1. Map of Toyama Prefecture, showing the sampling points of the Japanese common toad, *B. japonicus formosus*. 1. Itodani, Fukumitsu-machi (300 m in altitude); 2. Nakanokoochi, Fukumitsu-machi (400 m); 3. Ogaya, Jouhana-machi (400 m); 4. Jouyama, Kureha Hill, Toyama City (50 m); 5. Kamisasahara, Yatsuo-machi (200 m); 6. Koinami, Yatsuo-machi (500 m); 7. Kiritani, Yatsuo-machi (300 m); 8. Mt. Gozen, Oosawano-machi (325 m); 9. Bijyodaira, Ashikuraji, Tateyama-machi (1100 m); 10. Dainichidaira, Ashikuraji, Tateyama-machi (1730 m); 11. Midagahara, Ashikuraji, Tateyama-machi (1,850–2,040 m); 12. Mt.Sougadake, Unazuki-machi (970 m).

Results

The variation in male SVL was great, ranging from 65.7 to 137.5 mm, and the mean was 112.0 ± 3.83 (SE) mm. Similarly, females exhibited a wide SVL range, from 70.7 to 152.0 mm (X = 114.9 ± 7.65). The means of the two sexes were not significantly different (Student's t-test ; t = 0.374, dF = 40, .8>p>.7). The smallest individuals of both sexes were collected from the point, 1,730 m in altitude (point 10 in Fig. 1). The largest male was collected from 50 m in altitude (point 4), whereas the largest female from 970 m in altitude (point 12). Obviously, a toad from a higher region had a smaller SVL (Fig. 2).

Linear equations, Y = −0.0288X + 135.47 (Pearson's product-moment correlation coefficient, r = −0.797) for males, and Y = −0.0266X + 141.22 (r = −0.737) for females, were obtained and the correlations for these equations were highly significant (significance tests in correlation ; p <.01, dF = 28, and p<.01, dF = 10, respectively). The two equations did not differ in either slope or position (analysis of covariance ; F 1, 38 = 0.079, p>.05, and F 1, 39 = 2.398, p > .05, respectively), and the combined sexes showed an equation Y = −0.0272 X + 136.40 (r = −0.760). From this equation a 2.7 mm decrease in SVL per 100 m increase in altitude was predicted for the combined sexes.

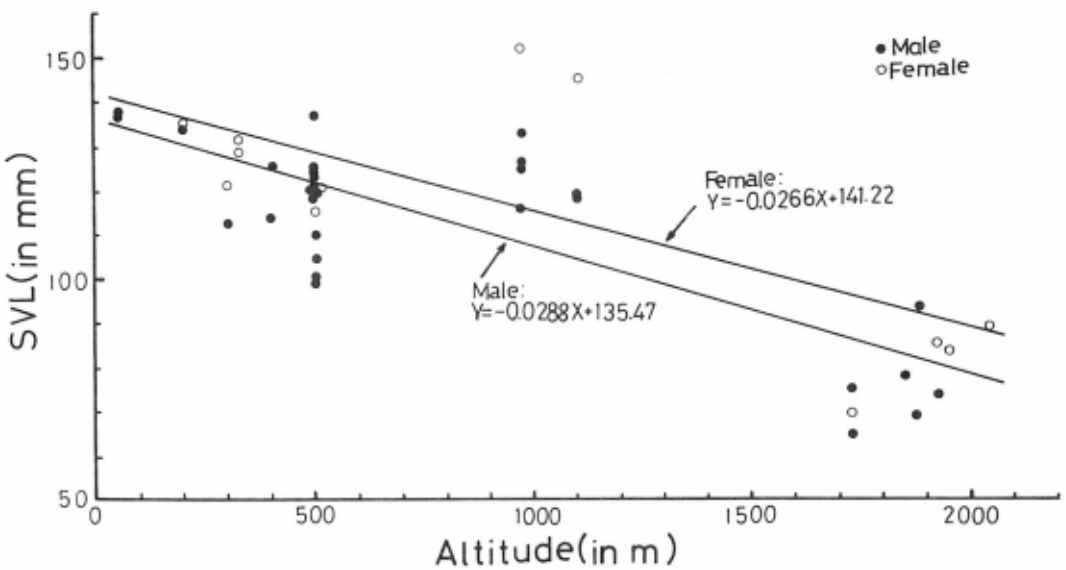


Fig. 2. Correlation between altitude and adult snout-vent length (SVL) in the Japanese common toad *B. japonicus formosus* from Toyama Prefecture. Closed circles, males ; open circles, females. Regression lines for two sexes are shown.

Discussion

OKADA (1937) split a montane form, *Bufo vulgaris montanus* from the lowland common toad, *B. v. formosus* (= *B. japonicus formosus*), partly based on the smaller body size of the former than in the latter form. The body size of the common toad, however, is affected by the altitude of the habitat as shown in the present results. Also, MATSUI (1984) has observed that the rate of SVL decrease for 100 m increase in altitude as 1.8 mm for males and 2.3 mm for females of the Japanese common toad populations from various localities of northeastern Japan. In the Japanese common toad, at least in the northeastern populations including those from Toyama Prefecture, populations from various altitudes can be regarded as forming a single cline in the body size, and this tendency contradicts recognizing two taxonomically different forms. At present, specimens from the regions between 1,200 and 1,600 m are lacking in our sample from Toyama Prefecture, and more pertinent conclusion on this problem will be drawn after including such materials in future analysis.

Factors affecting the altitudinal cline of the body size are yet to be clarified, but the shorter period of activity and scanter food source in higher regions would be the chief reason for the smaller body size. At the same time, there is a possibility that the body size variation is genetically controlled, and whether or not this holds for should be determined by rearing toads from various altitudes under an uniform laboratory condition.

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