Comparative Tooth Morphology and Qualitative Analysis on the Enamel Surface using Energy Dispersive X-ray Spectroscopy in the White-Toothed Shrew Crocidura lasiura and C. suaveolens and the Red-Toothed Shrew Sorex caecutiens from Korea

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The tooth morphology and qualitative mineral contents on enamel surface using energy dispersive X-ray spectroscopy, (EDX) were examined in the white-toothed shrew (genus Crocidura) Crocidura lasiura and C. suaveolens and the red-toothed shrew (genus Sorex) Sorex caecutiens. In the case of C. lasiura and C. suaveolens, dental formula was found I 3/1 C1/1 P1/1 M3/3=28. The upper 1st and 2nd molars had an unequal W-shape formed by 5 cusps on the crown. The 3rd molar was found one-third the size of those of 1st and 2nd molars. The upper 1st incisor had two different sized hook-shapes and the lower 1st incisor was even. In the case of S. caecutiens, dental formula was found to be I3/1 C1/1 P3/1 M3/3=32. The upper 1st 1st and 2nd molars had an equal W-shape on crown. The upper 3rd molar was half the size of those of the other molars. The upper 1st incisor possessed two similar sized hook-shapes and the lower 1st incisor had an uneven and serrated form. A comparison with the dental and cranial measurements revealed C. lasiura to be the largest of the three species (p < 0.001) and C. suaveolens and S. caecutiens were similar in size (p > 0.05). A qualitative analysis of mineral contents on enamel surface of the lower 1st incisor and lower 1st molar using EDX revealed C, O, P, Ca and Cu in all specimens and Pb was detected in several enamel specimens. No significant differences in the mineral contents (% weight) were observed among the three species (p > 0.05). Fe was only detected on enamel surface of S. caecutiens with red pigmented teeth. Therefore, Fe is responsible for the red tip of the teeth. These results suggest that tooth morphological characteristics including the color of the tooth tip might be used as the key classifying species belonging to Crocidura and Sorex.

Key Words: Crocidura lasiura, Crocidura suaveolens, Energy dispersive X-ray spectroscopy, Sorex caecutiens, Tooth
Introduction

The shrew belonging to insectivora is a small, short-legged, mouse-like mammal with short, dense, dark brown fur and extremely small eyes\(^1\). They are predatory and feed mainly on small invertebrates, particularly insects\(^1\). Shrews are the most primitive mammals with some of the earliest mammalian features and primitive characters\(^1-4\). Shrews are generally considered to consist of two subfamilies, the red-toothed shrew (genus *Sorex*) and the white-toothed shrew (genus *Crocidura*), according to their external morphological characteristics, particularly the color of the tooth tip\(^4-7\). Genus *Sorex* inhabiting Korea is believed to include two species, the little spider shrew *S. minutus* and the Korean spider shrew *S. caecutiens*\(^6\). Genus *Crocidura* that inhabits Korea is composed of three species, lesser white-toothed shrew *C. suaveolens*, Japanese white-toothed shrew *C. dsinezumi* and big white-toothed shrew *C. lasiura*\(^6\). The shrew is an important mediator controlling the population of invertebrates and small vertebrates in ecosystem\(^1,8,9\), but shrews are quite rare, often active only at night and their wild populations have decreased. Only a few reports have been published on the brief taxonomical status\(^4-7,10\), breeding ecology\(^11,12\) and histology of sperm\(^13,14\) and salivary gland\(^15-17\) of shrews inhabiting Korea, and even fewer on the red-toothed shrew *S. caecutiens*. Although studies on the tooth morphology of moles and shrews of foreign species belonging to insectivora show that their teeth have primitive and unique characteristics\(^1,4,18,19\), there are no reports on the tooth morphology of shrews inhabiting Korea.

This study examined the tooth morphological characteristics and qualitatively analyzed using energy dispersive X-ray spectroscopy (EDX) the mineral contents on the enamel surface of the white-toothed shrew *C. lasiura* and *C. suaveolens*, and the red-toothed shrew *S. caecutiens* inhabiting Korea.

Materials and Methods

A total of 55 *C. lasiura* (32 males, 22 females), 18 *C. suaveolens* (14 males, 4 females) and 2 *Sorex caecutiens* (1 male, 1 female) were collected with Sherman live traps at Daejeodong in Busan and Mt. Jiri in Gyeongsangnam-do from October 1994 to October 2000. All animal studies were approved by the ‘Institutional Animal Care and Use Committees’ at Chosun University, and animal care was carried out according to the ‘Guide for the Care and Use of Laboratory Animals’. The external morphological characters (body weight, length of head and body, tail, hind foot and ear) of the collected samples were measured and the samples were conserved in 70% alcohol after extraction of the skull. The age of each specimen was determined by the tooth wear of the upper 1st, 2nd and 3rd molars with reference to Koh\(^20\). The cranial characteristics (greatest length of skull and length of mandible) and tooth morphological characteristics (Length of upper 1st incisor to 1st molar, upper molar series, maxillary tooth-row, lower molar series and mandible tooth-row) of only adult specimens (44 *C. lasiura*; 17 *C. suaveolens*; 2 *S. caecutiens*) were measured using vernier calipers to the nearest 0.01 mm (Tajima, Nagoya, Japan) and observed using a stereoscope. The enamel specimens were prepared from the 14 lower 1st incisors and 14 lower 1st molars. All specimens were qualitatively analyzed for their mineral content (% weight) using EDX (Horiba, EDX7200-H, Kyoto, Japan). The measurements are expressed as the mean±SD. The cranial and dental measurements and mineral contents were tested by ANOVA. The regression lines of the dental measurements against the cranial measurements in each species were estimated to reveal the proportional differences of those dental parts. Statistical analyses were performed using PASW Statistics 18.0 (IBM Co., Armonk, NY, USA).

Results

1. Tooth morphology

1) *C. lasiura*

The dentition of the big white-toothed shrew *C. lasiura*, consists of a continuous row of typical white teeth with 3 incisors, 1 canine, 1 premolar and 3 molars in the maxilla and comprises 1 incisor, 1 canine, 1 premolar and 3 molars in the mandible, i.e. the dental formula is I3/1 C1/1 P1/1