

**KARYOTYPE OF THE HILL'S SHREW *CROCIDURA HILLIANA*  
JENKINS & SMITH, 1995 (MAMMALIA: INSECTIVORA:  
SORICIDAE) FROM CENTRAL THAILAND**

**Masaharu Motokawa**

*The Kyoto University Museum, Sakyo, Kyoto 606-8501, Japan.*

**Masashi Harada**

*Laboratory Animal Center, Osaka City University Medical School, Osaka 545-0051, Japan.*

**ABSTRACT.** - The conventional karyotype of the Hill's shrew *Crocidura hilliana* Jenkins & Smith, 1995 are reported for the first time based on a specimen obtained from central Thailand. The autosomes consist of four meta- or submetacentric, three subtelocentric and 17 acrocentric pairs. The X and Y sex chromosomes are submetacentric and subtelocentric, respectively. The diploid chromosome number and fundamental number are determined to be 50 and 66, respectively. This karyotype is different from the previously known karyotypes of the Palaearctic and Oriental species of this genus in having increased chromosome number and fundamental number.

**KEYWORDS.** - Karyotype, shrew, *Crocidura*, Mammalia.

---

**INTRODUCTION**

The white-toothed shrews of the genus *Crocidura* is the largest genus among mammals comprising at least 151 species distributed in the Palaearctic, Oriental and Afrotropical regions (Hutterer, 1993). Maddalena (1990), on the basis of electrophoretic analyses, divided this genus into two monophyletic groups, the Palaearctic and Oriental clade and the African clade. Maddalena & Ruedi (1994) reviewed the karyotypes of 38 species of this genus and proposed the ancestral karyotype in this genus to be  $2n = 38$  and  $FN = 54-58$  ( $2n$ : chromosome number,  $FN$ : fundamental number including two female sex chromosomes) consisting of four metacentric, three subtelocentric, and 11 acrocentric pairs, and metacentric X and acrocentric Y sex chromosomes. Maddalena & Ruedi (1994) subsequently considered two different karyological trends corresponding to the Maddalena's (1990) grouping: the Palaearctic and Oriental clade with stable or decreasing chromosome numbers from the ancestral condition and the African clade having increased ones. Subsequent karyological

data for 15 Oriental species agree well with this hypothesis (Ruedi & Vogel, 1995; Motokawa et al., 1997; Fang et al., 1997). The only exceptional case to this trend is the karyotype recorded from Thailand ( $2n = 50$ ,  $FN = 66$ ) by Tsuchiya et al. (1979). This karyotype was reported as of "*C. attenuata*", but the identification of this specimen is probably erroneous (Motokawa et al., 1997). Therefore, the karyological data for Thai specimens with accurate morphological identification are desired to test the hypothesis proposed by Maddalena & Ruedi (1994). According to Hutterer (1993), known species of this genus from Thailand are *C. fuliginosa* (Blyth, 1855), *C. attenuata* Milne-Edwards, 1872, *C. pullata* Miller, 1911, *C. monticola* Peters, 1870 and *C. horsfieldii* (Tomes, 1856), in the order of decreasing body sizes. Recently, Jenkins & Smith (1995) described *C. hilliana* as a new species, in which cranial size is intermediate between and overlapping with *C. fuliginosa* and *C. attenuata*, from Loei Province, northeastern Thailand. Of these six Thai species, three have been karyotyped, *C. fuliginosa* for Malayan sample (Ruedi et al., 1990; Ruedi & Vogel, 1995), *C. attenuata* for Taiwanese sample (Motokawa et al., 1997; Fang et al., 1997), and *C. horsfieldii* for Indian sample (Krishna Rao & Aswathanarayana, 1978), but the remaining three have not been karyologically studied.



Fig. 1. The map of Thailand showing the sampling locality of *Crocidura hilliana* (OCUMS 3279) examined in this study.

In 1979, one of us (MH) collected one specimen of *Crocidura* from central Thailand and examined the conventional karyotype. Recently we identify this specimen to be *C. hilliana* based on the morphology of the cranium and dentition. In this paper, we report the conventional karyotype of *C. hilliana* on the basis of this specimen. We also describe the external characters of *C. hilliana*, which have not been known previously because all of the type materials were recovered from owl pellets (Jenkins & Smith, 1995).

## MATERIALS AND METHODS

One male specimen of *Crocidura hilliana* was collected from Sakaerat Station, Nakhon Ratchasima Province in the central part of Thailand by MH on 18 November 1979 (Fig. 1), which is currently deposited in the Laboratory Animal Center, Osaka City University Medical School (OCUMS) with catalog number of 3279. Cranial and dental measurements were taken using dial calipers ( $\pm 0.1$  mm) following Jenkins & Smith (1995). Cytological preparations were made from tail tissue culture cells by using standard air drying methods described in Harada & Yosida (1978). Nomenclature of chromosomes follows Maddalena & Ruedi (1994).

## RESULTS

The cranium and the dentition of OCUMS 3279 (Fig. 2) coincided well with the combined diagnostic characters of *C. hilliana* (Jenkins & Smith, 1995): broad and angular zygomatic process of maxilla, narrow interorbital region, broad and deep coronoid process, robust upper and lower first incisors, large and broad first upper unicuspid compared with the other unicuspid, and talonid of the third lower molar reduced to a single cusp. This specimen also agrees with the remaining description of *C. hilliana* by Jenkins & Smith (1995) and it is identified as *C. hilliana*. Its cranial measurements in mm are: condylobasal length 22.8, upper toothrow length 10.1, maxillary breadth at level of  $M^2$  7.4, interorbital breadth 4.5, braincase breadth 9.9, mandible length excluding  $I_1$  11.5, mandible height 5.8. These

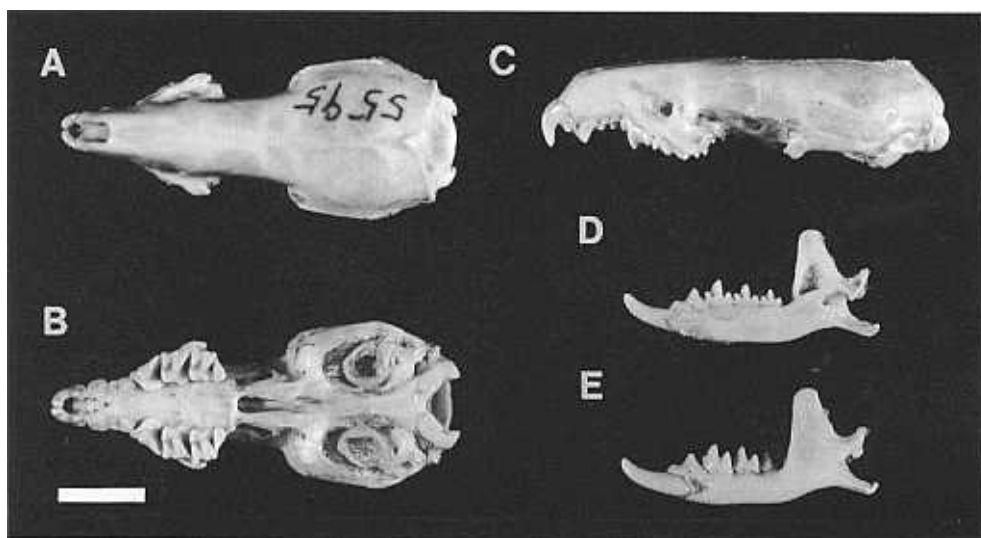


Fig. 2. Skull and mandible of *Crocidura hilliana* from Nakhon Ratchasima Province in Thailand (OCUMS 3279). Dorsal (A), ventral (B) and left lateral (C) views of skull, and lingual (D) and lateral (E) views of mandible are shown. The bar represents 5 mm.

measurements are within the variation of those reported for *C. hilliana* by Jenkins & Smith (1995) with exception of the maxillary breadth at level of  $M^2$ , which is slightly larger than that of the original description (6.0-7.2 in range, Jenkins & Smith, 1995). Its relative interorbital breadth in relation to maxillary breadth (60.8 %) is within the range (60.5-70.5 %) of the original data for *C. hilliana*, but smaller than those for *C. attenuata* (68.3-77.7 %) and *C. fuliginosa* (65.7-75.4 %) (Jenkins & Smith, 1995).

The external characters are examined from ethanol preserved body. The skull had already been removed so that the total length could not be measured. The tail skin had been separated from the tail bone which is 45.4 mm in length. The long bristle hairs on the tail are very abundant and observed on about 85% of the base of the tail and the longest one exceed 7 mm in length. Hind foot length is 14.3 mm without claw and 15.0 mm with claw, and the forefoot

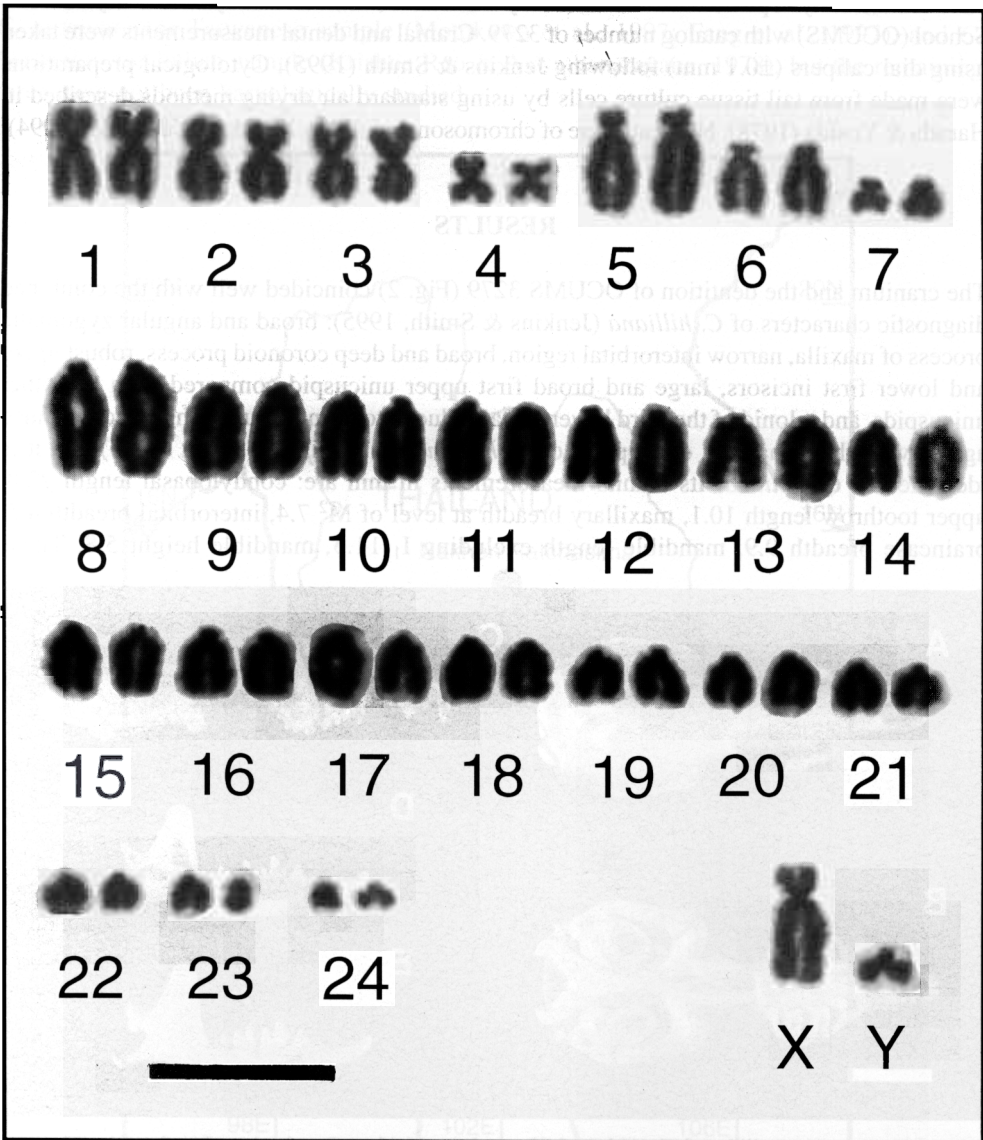


Fig. 3. Conventional karyotype of *Crocidura hilliana* from Nakhon Ratchasima Province in Thailand (OCUMS 3279). The bar represents 10  $\mu$ m.

length is 9.8 mm without claw and 10.4 mm with claw. The colour of the shrew kept in fluid is uniformly dark brown, while the snout, ears, hands, feet and tail are lighter in colour.

Thirty-five metaphase cells of OCUMS 3279 were observed and the conventional karyotype is shown in Fig. 3. The autosomes consist of four meta- or submetacentric (nos. 1-4), three subtelocentric (nos. 5-7) and 17 acrocentric (nos. 8-24) pairs in all of the cells examined. The X and Y sex chromosomes are submetacentric and subtelocentric, respectively. The diploid chromosome number and the fundamental number are determined to be 50 and 66, respectively.

## DISCUSSION

Hutterer (1993) recognized five *Crocidura* species (*C. fuliginosa*, *C. attenuata*, *C. pullata*, *C. monticola* and *C. horsfieldii*) from Thailand and Jenkins & Smith (1995) subsequently described *C. hilliana* as a new species from the northeastern Thailand. Of these, *C. hilliana* is morphologically different from *C. pullata*, *C. monticola* and *C. horsfieldii* in larger cranial size and from *C. fuliginosa* and *C. attenuata* mainly in their cranial shape (Jenkins & Smith, 1995). Of these Thai species, the karyological studies have been made on four species: *C. fuliginosa* for Malayan sample ( $2n = 40$ , FN = 54-58; Ruedi et al., 1990; Ruedi & Vogel, 1995), *C. hilliana* for Thai sample ( $2n = 50$ , FN = 66; present study), *C. attenuata* for Taiwanese sample ( $2n = 40$ , FN = 56; Motokawa et al., 1997; Fang et al., 1997) and *C. horsfieldii* for Indian sample ( $2n = 38$ , FN = 54; Krishna Rao & Aswathanarayana, 1978). These results suggest the karyological differentiation of *C. hilliana* from similar sized *C. fuliginosa* and *C. attenuata*, and smaller *C. horsfieldii* in Thailand.

Tsuchiya et al. (1979) reported the karyotype of  $2n = 50$  and FN = 66 of one female collected from Amphour Maung, Loburi Province, the central Thailand, identified as *C. attenuata* using the key by Lekagul & McNeely (1977), who confused *C. fuliginosa* with *C. attenuata* (Heaney & Timm, 1983). The sex chromosomes were not identified, because this specimen was female. As discussed by Motokawa et al. (1997), this karyotype is different from that of *C. attenuata* from Taiwan ( $2n = 40$ , FN = 56). This situation was probably caused by the erroneous identification by Tsuchiya et al. (1979). According to Tsuchiya et al. (1979), this  $2n = 50$  karyotype consisted of six meta- or submetacentric, two subtelocentric, and 17 acrocentric pairs. This karyotype is quite similar to that of *C. hilliana*, because the largest and the smallest meta- or submetacentric pairs seem to be identical with the X sex chromosomes and the smallest subtelocentric pair (no. 7), respectively, in that of *C. hilliana* in the present study. Examination of Tsuchiya et al.'s (1979) specimen is desired to confirm the identification on the basis of morphological features.

The karyotype of *C. hilliana* is different from all of the previously known karyotypes of this genus from the Palaearctic and Oriental regions. According to the hypothesis of Maddalena & Ruedi (1994), the Palaearctic and Oriental species have stable or decreasing chromosome numbers from the ancestral condition, with  $2n = 38$  and FN = 54-58. The karyotype of *C. hilliana*, however, has the increased chromosome number ( $2n = 50$ ) from the ancestral condition of Maddalena & Ruedi (1994), and it is also characterized by the larger value of the fundamental number (FN = 66) among the Palaearctic and Oriental species. It is suggested that *C. hilliana* evolved from the ancestral condition by increasing both chromosome number and fundamental number. This exceptional karyotype of this species is most similar to that of *C. malayana* Robinson & Kloss, 1911 *sensu* Ruedi, 1995 from Malay Peninsula ( $2n = 38$ -

40, FN = 62-68; Ruedi et al., 1990; Maddalena & Ruedi, 1994; Ruedi & Vogel, 1995) in fundamental number, but the former is quite different from the latter in chromosomal morphology. Future karyological studies including banding techniques for continental Asian species around Thailand (e.g., *C. pullata* and *C. monticola*) are desired to reconstruct the detailed process of chromosomal evolution of the exceptional karyotype of *C. hilliana* within the Palaearctic and Oriental species.

#### ACKNOWLEDGMENTS

We are grateful to Dr. N. Ratanawarabhan of Thailand Institute of Scientific and Technological Research for her valuable advice and assistance during field survey of MH in Thailand. We thank Drs. P.D. Jenkins and T. Hikida for their critical comments on early drafts of the manuscripts.

#### LITERATURE CITED

- Fang, Y. P., L. L. Lee., F. H. Yew & H. T. Yu, 1997. Systematics of white-toothed shrews (*Crocidura*) (Mammalia: Insectivora: Soricidae) of Taiwan: karyological and morphological studies. *J. Zool., Lond.* **242**: 151-166.
- Harada, M. & T. H. Yosida, 1978. Karyological study of four Japanese *Myotis* bats (Chiroptera, Mammalia). *Chromosoma*, **65**: 283-291.
- Heaney, L. R. & R. M. Timm, 1983. Systematics and distribution of shrews of the genus *Crocidura* (Mammalia: Insectivora) in Vietnam. *Proc. Biol. Soc. Wash.*, **96**: 115-120.
- Hutterer, R., 1993. Order Insectivora. In: Wilson, D. E. & D. M. Reeder (ed.), *Mammal species of the world*. Pp. 69-130. Smithsonian Institution Press, Washington.
- Jenkins, P. D. & A. L. Smith, 1995. A new species of *Crocidura* (Insectivora: Soricidae) recovered from owl pellets in Thailand. *Bull. nat. Hist. Mus. Lond. (Zool.)*, **61**: 103-109.
- Krishna Rao, S. & N. V. Aswathanarayana, 1978. Karyological analysis of the Horsfield's shrew from peninsular India. *J. Hered.*, **69**: 202-204.
- Lekagul, B. & J. A. McNecly, 1977. *Mammals of Thailand*. Kurusapha Ladprao Press, Bangkok. 758 pp.
- Maddalena, T., 1990. Systematics and biogeography of Afrotropical and Palaearctic shrews of the genus *Crocidura* (Insectivora: Soricidae): a electrophoretic approach. In: Peters, G. & R. Hutterer (ed.), *Vertebrates in the tropics*. Pp. 297-308. Museum Alexander Koenig, Bonn.
- Maddalena, T. & M. Ruedi, 1994. Chromosomal evolution in the genus *Crocidura* (Insectivora: Soricidae). *Spec. Publ. Carnegie Mus. Nat. Hist.*, **18**: 335-344.
- Motokawa, M., M. Harada, L.-K. Lin, K. Koyasu & S. Hattori, 1997. Karyological study of the gray shrew *Crocidura attenuata* (Mammalia: Insectivora) from Taiwan. *Zool. Stud.*, **36**: 70-73.
- Ruedi, M., 1995. Taxonomic revision of shrews of the genus *Crocidura* from the Sunda shelf and Sulawesi with description of two new species (Mammalia: Soricidae). *Zool. J. Linn. Soc.*, **115**: 211-265.
- Ruedi, M., T. Maddalena, H. S. Yong & P. Vogel, 1990. The *Crocidura fuliginosa* species complex (Mammalia: Insectivora) in peninsular Malaysia: biological, karyological and genetical evidence. *Biochem. Syst. Ecol.*, **18**: 573-582.
- Ruedi, M. & P. Vogel, 1995. Chromosomal evolution and zoogeographic origin of southeast Asian shrew (genus *Crocidura*). *Experientia*, **51**: 174-178.
- Tsuchiya, K., T. H. Yosida, K. Moriwaki, S. Ohtani, S. Kulta-Uthai & P. Sudto, 1979. Karyotypes of twelve species of small mammals from Thailand. *Rep. Hokkaido Inst. Publ. Health*, **29**: 26-29. (in Japanese).