

carotid labyrinth is similar to that described for *C. batrachus*. *R. rita* (figure 4) presents a case of morphological variation, with the carotid labyrinth showing an enormous capillary plexus surrounding a large anterior section of a prolongation of the lateral dorsal aorta beyond the point where the 1st efferent branchial artery meets it.

From the above findings it is clear that the amphibian type of carotid labyrinth is present in all the catfish teleosts examined, irrespective of their air-breathing habit. Similarities in histology and topographical relationship with the external carotid artery and with the internal carotid artery point to a homology between the carotid labyrinths of the two. It remains to be determined whether a carotid labyrinth has evolved in other groups of teleosts.

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The C-banding pattern of 6 Japanese species of vespertilionine bats (Mammalia: Chiroptera)

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Summary. The C-banding patterns of 6 species of Japanese vespertilionine bats are presented. The variation in amount and distribution of heterochromatin indicates that deletions and additions of heterochromatin have contributed to the karyotypic diversity in Vespertilioninae.

It has been assumed, from conventional data, that various derived karyotypes found in many species within Vespertilioninae are mainly differentiated from that of *Myotis* ($2n=44$, FN=50) by centric fusion²⁻⁴. Further, this hypothesis has been supported by the comparison of C- and G-banding patterns of American vespertilionid bats⁵. In this paper, we report C-band patterns of 6 Japanese species belonging to 4 genera (*Myotis*, *Pipistrellus*, *Nyctalus* and *Vespertilio*) of the Vespertilioninae, and the karyotypic evolution within this subfamily is reviewed in connection with the characteristics of their C-bands.

The air dry method described by Uchida and Andō⁶ was used for karyotypic analysis. Chromosomal classification followed the method of Patton⁷. The C-banding procedure was essentially identical with that of Sumner⁸.

As shown in the figure, a and b, most of the autosomal elements and the (sub-)metacentric X chromosomes in 2 *Myotis* species, *M. frater* and *M. macrodactylus*, have distinct centromeric C-bands, except 1 pair of large biarmed autosomes (very obscure centromeric C-band), 1 pair of small ones (centromeric C-band and heterochromatic short arm) and the small (sub-)metacentric Y chromosomes which are totally heterochromatic. These results are in good agreement with those for the same species described by Harada and Yosida⁹, and are strikingly similar to those for 2 other Japanese⁹, 2 European and 11 American species¹¹ of this genus.

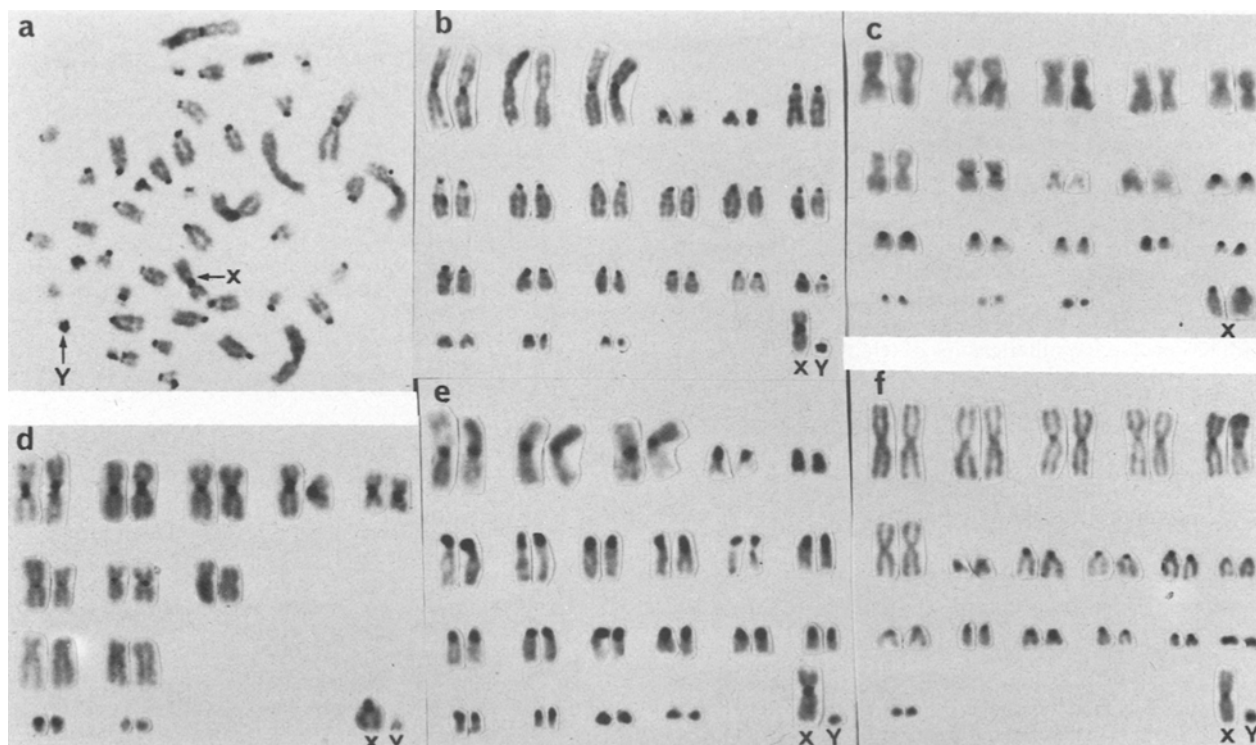
Only the second smallest pair of the biarmed autosomal complement in *P. endoi* (figure, c) has a distinct centromeric C-band, the remaining pairs have little or no C-band material. The largest and the second smallest pairs of its unarmed autosomal series are completely C-band negative, while the smallest pair appears totally heterochromatic. The remaining pairs of unarmed autosomes have distinct centromeric C-bands. The acrocentric X chromosome has a centromeric C-band.

The C-banding pattern of *P. abramus* (figure, d) has been reported previously¹², but the banding pattern of its Y chromosome has remained unknown. 5 pairs of large-to medium-sized biarmed autosomes and a pair of small

acrocentrics have large centromeric C-bands. 2 pairs of medium-sized biarmed ones have tiny centromeric C-bands. The remaining autosomal elements have no detectable bands in this material. The acrocentric X chromosome, possessing a visible secondary arm, is deeply stained from the centromeric region to the short arm, but the small acrocentric Y chromosome is completely C-band negative. The amount of constituent heterochromatin in individual autosomal sets in *N. furvus* (figure, e) is very high. Autosomal pairs are characterized by large centromeric C-band regions or they are entirely heterochromatic. The (sub-)metacentric X chromosome has a distinct centromeric C-band, and the small acrocentric Y chromosome is totally heterochromatic.

The C-banding pattern observed in *V. superans* (figure, f) is similar to that of *V. orientalis*¹³, except for minor differences. 2 pairs of large biarmed autosomes and a pair of the smallest ones have obscure centromeric C-bands. The remaining pairs of this series do not possess distinct C-bands. The smallest and the second smallest pairs of its unarmed autosomal complement are completely C-band positive, and most of the remaining pairs have centromeric C-bands. The (sub-)metacentric X chromosome possesses an obscure centromeric C-band, and the small acrocentric Y is totally heterochromatic.

The C-band variation found in the 6 species, in connection with their taxonomic allocation within their subfamily and the direction of karyotypic evolution, would be explained in terms of the interpretations outlined below. It has been assumed that *Pipistrellus* is phylogenetically a specialized form which derived from a *Myotis*-like ancestor, and that *Vespertilio* is a specialized offshoot of a *Pipistrellus*-like form, both being placed in the tribe Pipistrellini. Indeed, *P. endoi* and *V. superans* have rather differentiated karyotypes, and the increase in their large biarmed autosomal elements is due to the centric fusion of the unarmed elements, such as those found in *Myotis*. Most of the biarmed elements in *P. endoi* and *V. superans*, however, do not show distinct heterochromatin. The above facts and the existence of distinct C-bands on large unarmed autosomes



A comparison of the C-banding patterns of 6 Japanese vespertilionine bats a) *Myotis frater*; b) *Myotis macrodactylus*; c) *Pipistrellus endoi*; d) *Pipistrellus abramus*; e) *Nyctalus fuvvus*; f) *Vespertilio superans*.

in *Myotis*, seem to indicate that the process of centric fusion has been accompanied by the deletion of heterochromatin.

P. endoi and *P. abramus* are so closely related that they should both be placed in the specialized *javanicus* species group¹⁴. But each species retains a fairly different karyotype. Similarly, the distribution of heterochromatin on the complement of *P. abramus* differs remarkably from that of *P. endoi*. Namely, the biarmed autosomes of the former contain a relatively high amount of C-band material. From morphological evidence, *P. abramus* is a more advanced form than *P. endoi*¹⁵. In fact, the karyotype of the former is the most derived among those of the 'old world' species of *Pipistrellus*^{2,16-21}. Considering the above, the C-band pattern found in the biarmed autosomes of *P. abramus*, especially in 5 pairs (the 1st row), appears to have been brought about, during the course of its karyotypic alteration from that of *P. endoi* or after that time, by the addition of heterochromatin. It is also possible to make another interpretation for this C-band variation. Namely, *P. endoi* and *P. abramus* evolved independently from a common ancestor with a high diploid number, and the process of centric fusion was accompanied by loss of heterochromatin in *P. endoi*, but heterochromatin was conserved in the karyotypic alteration of *P. abramus*.

The karyotype of *N. fuvvus* is strikingly similar to that of *Myotis*. However, the amount of C-band contained in the autosomal complement of *N. fuvvus* is evidently high as compared with that of *Myotis*. Considering that *Nyctalus* is a direct offshoot of *Pipistrellus*²², the existence of high amounts of heterochromatin in *N. fuvvus* seems to indicate that the extensive addition of heterochromatin has occurred at the time of the divergence of *Nyctalus* from a certain pipistrelle species having a *Myotis*-like karyotype. Thus, our data suggest the possibility that the deletion and the

addition of heterochromatin, besides centric fusions, have played a role in the karyotypic evolution within Vespertilioninae, especially the tribe Pipistrellini.

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