Objectives and methods of the study

Paleontological study of echinoid fossils collected from the northern part of Ibaraki Prefecture was carried out. At the same time, stratigraphical study of the Tertiary System distributed in this area has been examined and some new strata are established herein.

Paleontological study of echinoid fossils

1) Taxonomical study of the echinoid fossils yielded from the each area has been done with systematic examination of echinoid fossils.
2) Analysis of echinoid fossil assemblage is made mainly to reconstruct the habits and habitats of echinoid taxa.
3) Faunal changes of the echinoid fossils during the early middle Miocene to Pliocene have been discussed with consideration of origin and migration of echinoid fossils in the Japanese Islands.

Stratigraphical study

1) The studied area was divided into the 13 sub-areas and established the stratigraphy of the each area.
2) Systematic stratigraphical correlation of the sub-areas is carried out as followed many stratigraphical studies such

as Otsuki (1975), Maruyama (1984), Koizumi (1985), Takahashi (1986), Yanagisawa *et al.*, (1989), Yanagisawa (1990), Yanagisawa and Akiba (1998), Saito *et al.*, (1992), Noda *et* al., (1994, 1995), Yoshioka *et al.*, (2001), Koda *et al.*, (2003) and others.

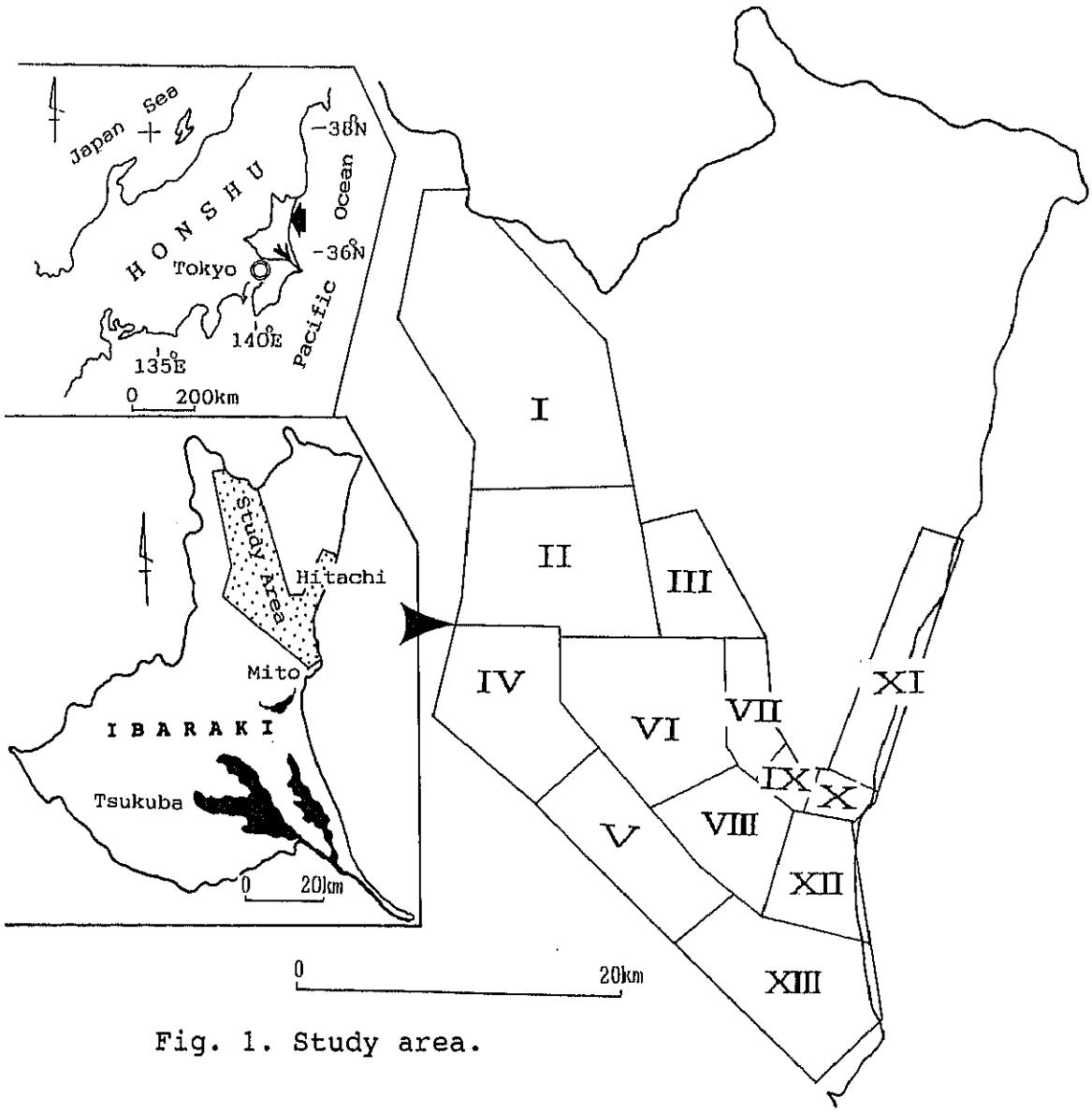


Fig. 1. Study area.

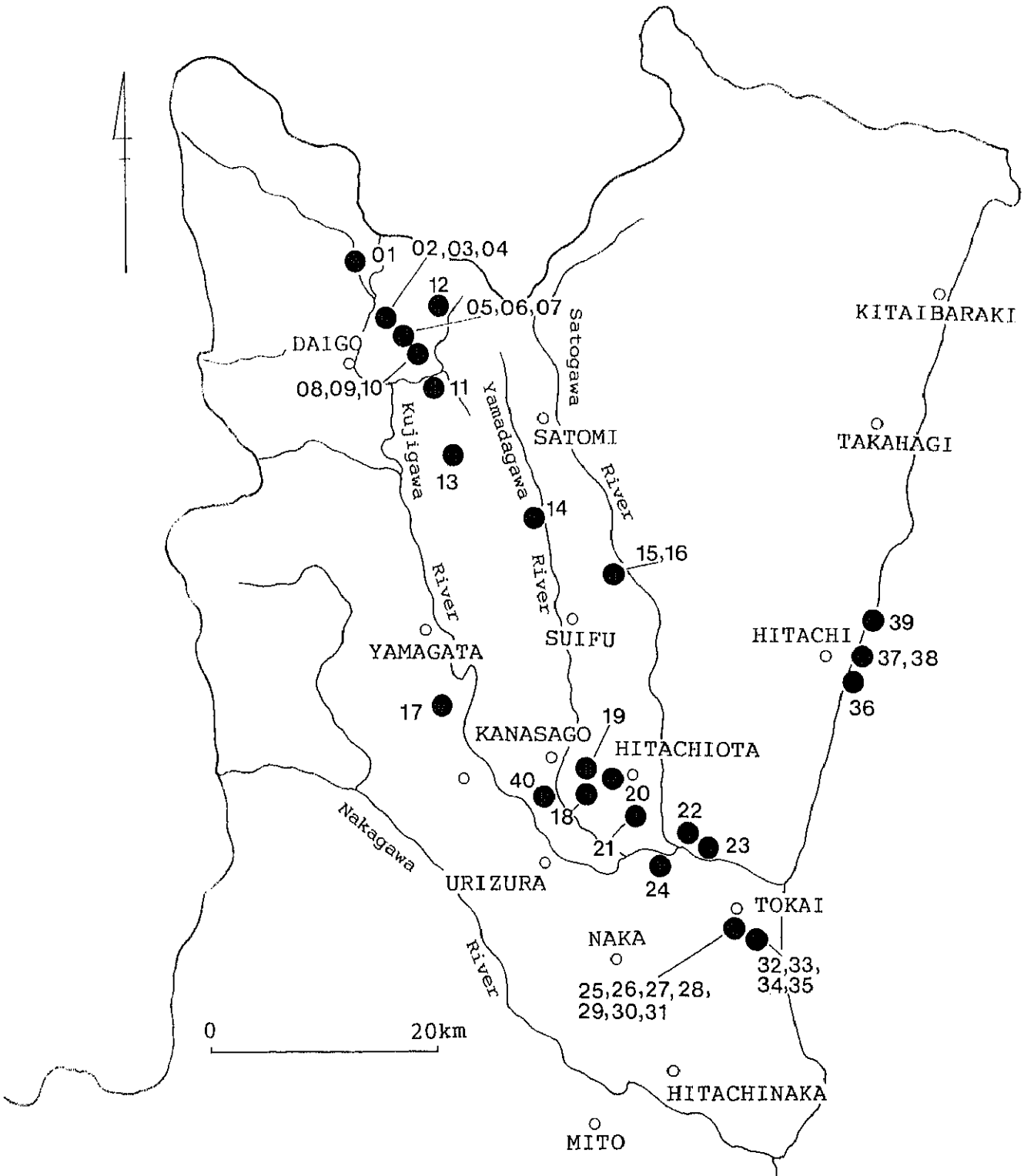
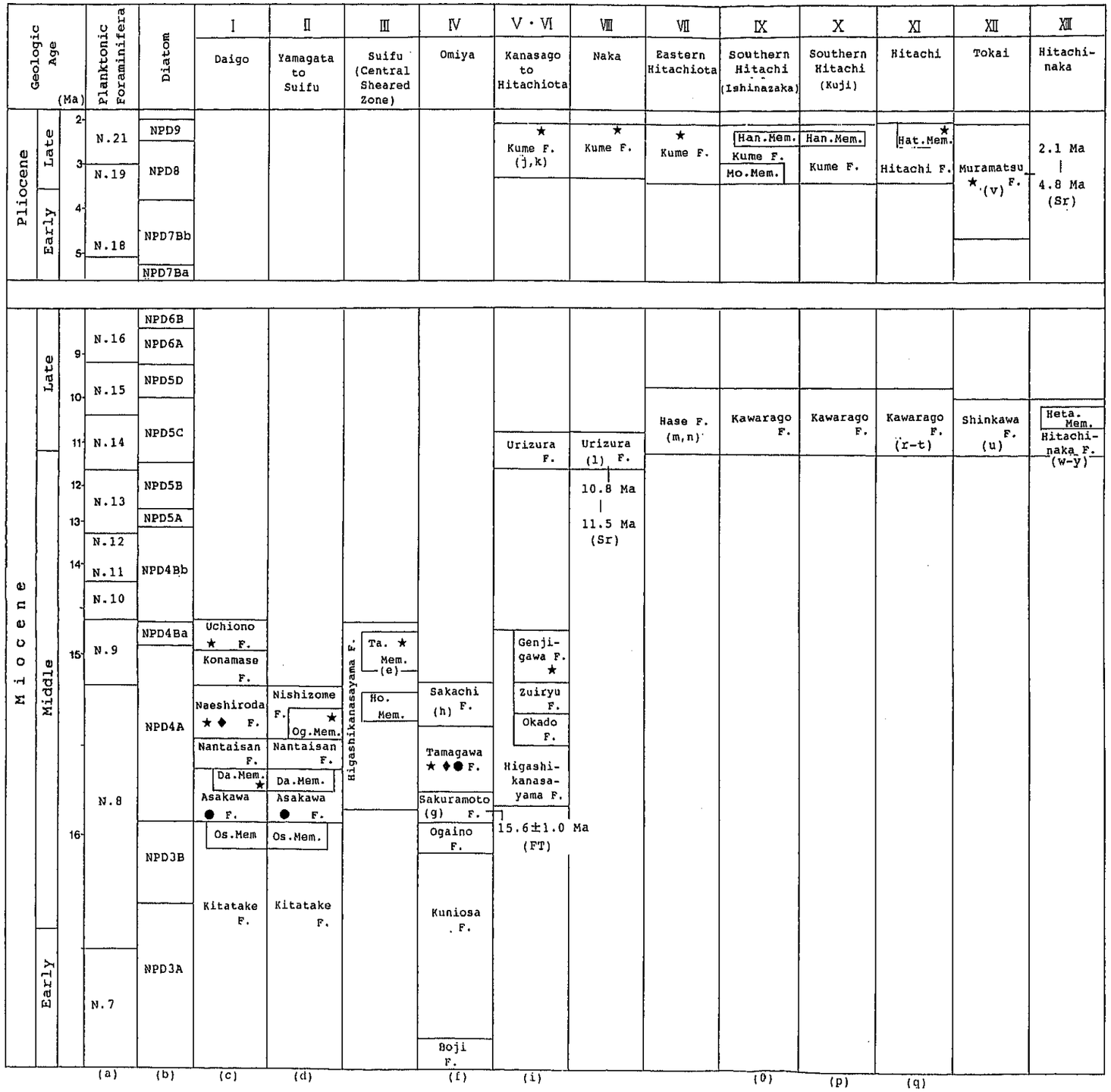


Fig. 2. Localities of echinoid fossils in the northern part of the Ibaraki Prefecture (●).

Table 1. Stratigraphic division and correlation of the Tertiary System in the northern part of Ibaraki Prefecture.



Os.Mem.; Osawaguchi Tuff Member, Da.Mem.; Daienji Siltstone Member, Og.Mem; Oginokubo Siltstone Member, Ho.Mem; Hosokusa Sandstone Member, Ta.Mem.; Tatsukuroiso Mudstone Member, Heta.Mem.; Hetano Tuff Member, Mo.Mem.; Momiya Conglomerate Member, Han.Mem.; Hanareyama Tuff Member, Hat.Mem.; Hatsuzaki Sandstone Member.

★; stratigraphic occurrence of echinoids fossil.

◆; stratigraphic occurrence of *Miogypsina* and *Operculina* of folamimiferal fossil.

●; stratigraphic occurrence of Arcid-Potamid fauna of molluscan fossil.

(a) planktonic foraminifera zones by Blow (1969), (b) Diatom zones by Yanagisawa and Akiba(1998), (c) Kikuchi and Nikaido (1996), (d,I, m) Amano *et al.* (1989), (e) Koizum (1973), (f) Noda *et al.* (1994), (g) Koda *et al.*, (2003), (h) Yanagisawa (1990), (j, k) Takahashi (1986) and Akiba (1988), (l, v) Ito and Kikuchi (un-publication data), (n) Yanagisawa (1989), (o, p) Kikuchi *et al.* (1992), (q) Noda *et al.*, (1995), (r-t) Maruyama (1984), Yanagisawa (1989) and Sudo *et al.* (2002), (u) Takada (1999MS),(w-y) Maruyama (1984), Yanagisawa (1989) and Takada(1999MS).

FT; fission track age by Koda *et al.*, (2003).

Sr; Strontium isotope age by Ito and Kikuchi (un-Publication).