Memoir of the Fukui Prefectural Dinosaur Museum 9: 1–7 (2010)

A LATE MIDDLE JURASSIC BOREAL BELEMNITE *CYLINDROTEUTHIS* FROM CENTRAL JAPAN AND ITS PALEOBIOGEOGRAPHIC IMPLICATIONS

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ABSTRACT

A single rostrum of *Cylindroteuthis* (*Cylindroteuthis*) cf. *theofilaktovi* Nikitin recovered from the Late Bathonian–Early Callovian Kaizara Formation of the Tetori Group in Shimoyama, Kuzuryu area, Central Japan, is described for the first time in East Asia. This belemnite species has been previously known only from the Early Callovian of Central Ukraine in Eastern Europe. Since the family Cylindroteuthididae has been considered as the typical Boreal or northern element in the Jurassic belemnite paleobiogeographic studies, its occurrence in the Inner Zone (Japan Sea side) of Southwest Japan clearly indicates that *Cylindroteuthis* expanded its distribution to the mid-latitudes of the Northwest Pacific at that time. This expansion possibly corresponds to the Early Callovian spread of boreal cylindroteuthids toward south into Europe in the Boreal-Atlantic seas. The occurrence of *Cylindroteuthis* from the Kaizara Formation strongly suggests that a cooler current possibly from the Arctic reached the Tetori Basin in the Late Bathonian–Early Callovian time.

Key words: *Cylindroteuthis*, belemnites, Late Bathonian–Early Callovian, Kaizara Formation, Tetori Group, Central Japan

佐野晋一・後藤道治・Oksana S. DZYUBA ・伊庭靖弘（2010）福井県東部九頭竜地域の中部ジュラ系上部貝皿層からのボレアル要素ベレムナイト *Cylindroteuthis* の発見と古生物地理学上の意義．福井県立恐竜博物館紀要 9：1－7.

福井県東部の九頭竜地域下山の手取層群九頭竜亜層群貝皿層由来と考えられるベレムナイト *Cylindroteuthis* (*Cylindroteuthis*) cf. *theofilaktovi* Nikitinの鞘一標本を記載した．本種は従来ヨーロッパ東部ウクライナのCallovian前期の地層のみに知られ，模式地以外からの初産出記録となる．ジュラ紀ベレムナイト古生物地理においてシリンドロチューティス科は典型的なボレアルもしくは北方要素とされ，下山からの産出は本科がBathonian後期～Callovian前期に北西太平洋域において中緯度地域にまで分布を広げていたことを示し，Callovian前期にヨーロッパで本科が南に分布を拡大したイベントに対応する可能性がある．また，当時，北極由来の海流が手取堆積盆に到達していたことを強く示唆する．

INTRODUCTION

Belemnites are the extinct coleoid cephalopods, which flourished worldwide in the Jurasso–Cretaceous oceans (Doyle et al., 1994). The distribution of belemnite genera and families has been considered as an important indicator for the establishment of paleobiogeographic provinces and/or realms and their changes (e.g., Saks et al., 1971; Doyle, 1987; Challinor et al., 1992). Belemnites have been discovered at many localities of the marine Mesozoic strata of Japan (e.g., Hanai, 1953; Kano and Sano, 1998), with several species described or figured in scientific literatures (Yokoyama, 1904; Hanai, 1953; Takei, 1959; Hirano and Sano, 1977; Kumon and Umezawa, 2001; Niko and Hayakawa, 2005; Niko and Kametani, 2006).

Received May 19, 2010. Accepted September 2, 2010.
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Occurrence of belemnites in the Kuzuryu area, Central Japan, has been known for a few decades. For example, a well-preserved specimen was figured in the fossil atlas (Hamada and Itoigawa, 1983). However, paleontological studies of belemnite specimens have not been conducted. In this paper, a single rostrum of *Cylindroteuthis* (*Cylindroteuthis*) cf. *theofilaktovi* Nikitin from the Late Bathonian–Early Callovian Kaizara Formation of the Tetori Group is described for the first time in East Asia. This belemnite species has been known only from the Lower Callovian in Eastern Europe (Nikitin, 1969), though this supposed limited occurrence may be caused by poor information about the Arctic and North Pacific Callovian belemnites (Dzyuba, 2004). Since the family Cylindroteuthididae has been considered as the typical Boreal or northern element in the Jurassic belemnite paleobiogeographic studies (e.g., Saks and Nalnyaeva, 1966, 1979; Doyle, 1987; Dzyuba, 2005), its occurrence in the Inner Zone (Japan Sea side) of Southwest Japan clearly indicates that *Cylindroteuthis* expanded its distribution to the mid-latitudes of the Northwest Pacific at that time. The occurrence of *Cylindroteuthis* strongly suggests that a cooler current possibly from the Arctic reached the Tetori Basin in the Late Bathonian–Early Callovian time.

The belemnite specimen described herein is deposited in the Fukui Prefectural Dinosaur Museum (FPDM). Morphological terminologies employed in the systematic paleontology are derived from Doyle and Kelly (1988).

GEOLOGIC SETTING

The Middle Jurassic–Early Cretaceous Tetori Group, which is composed of marine to non-marine siliciclastic rocks, sporadically distributed in the northern part of Central Japan (Maeda, 1961) (Fig. 1A). The Tetori Basin, where the Tetori Group was deposited, was located to the northeast of the Korean Peninsula before the opening of the Japan Sea in the Miocene epoch (e.g., Okada and Sakai, 2000). Thus the Tetori Group deposited in the mid-latitudes of the eastern margin of the Asian Continent at that time. The lower part of the Tetori Group, called the Kuzuryu Subgroup, contains marine argillaceous Kaizara Formation in its upper part (Maeda, 1961; Yamada and Uemura, 2008). The age of the Kaizara Formation is well constrained by ammonoids, and three ammonoid zones were established (Sato and Westermann, 1991): *Pseudoneuqueniceras yokoyamai* assemblage zone (latest Bathonian), *Kepplerites japonicum* assemblage zone (earliest Callovian) and *Oxycerites* assemblage zone (Early Callovian) toward the top of the sequence.

A belemnite rostrum described herein was most probably recovered in Shimoyama, Kuzuryu area, Fukui Prefecture, Central Japan (Fig. 1B), according to the label used for the permanent exhibition of the Fukui Prefectural Museum, an ascendant of the Fukui Prefectural Dinosaur Museum. Shimoyama is well known by marine molluscan fossils from the Kaizara Formation. Several ammonoids, such as *Pseudoneuqueniceras* and *Kepplerites* (*Seymourites*), have been recovered from Shimoyama (Kobayashi, 1947; Sato, 1960, 1962; Fukui City Museum of Natural History, 1997). Recent

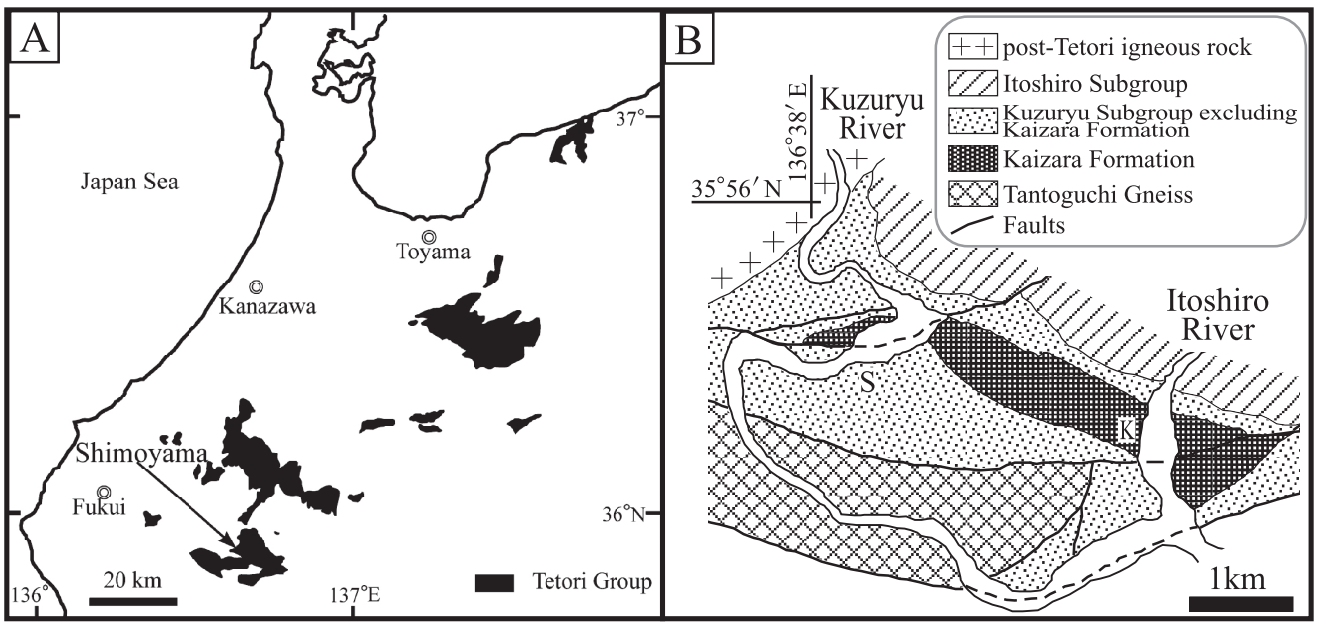

FIGURE 1. **A**, Distribution of the Tetori Group in Central Japan and locality of the Shimoyama *Cylindroteuthis*; **B**, Geologic map of the main distributional area of the Kaizara Formation of the Kuzuryu Subgroup of the Tetori Group (modified from Yamada et al., 1989). S and K represent the Shimoyama and Kaizara villages, which are the famous fossil localities of the Kaizara Formation, respectively.

ammonoid biostratigraphic studies of the Kaizara Formation suggest that whole part of the Kaizara Formation probably cropped out in Shimoyama (Handa et al., 2008; Matsuoka et al., 2008; Handa, personal communications, April 15, 2010). The age of the Shimoyama belemnite is assigned to the Late Bathonian–Early Callovian.

SYSTEMATIC PALEONTOLOGY

Order BELEMNITIDA MacGillivray, 1840
Suborder BELEMNITINA MacGillivray, 1840
Family CYLINDROTEUTHIDIDAE Stolley, 1919
Genus *CYLINDROTEUTHIS* Bayle 1878
Subgenus *CYLINDROTEUTHIS* Bayle 1878

Cylindroteuthis (*Cylindroteuthis*) cf. *theofilaktovi* Nikitin, 1969
(Fig. 2)

Material.—A single incomplete rostrum (FPDM-I-181) most probably recovered from the Kaizara Formation of the Kuzuryu Subgroup of the Tetori Group, in Shimoyama, the Kuzuryu area, Fukui Prefecture, Central Japan.

Dimensions.—Total preserved length 100.6 mm
Dorso-ventral diameter at forward end 12.2 mm
Lateral diameter at forward end 11.5 mm

Description.—Large, elongate, cylindrical rostrum with symmetrical outline (Figs. 2A–C). Tip of the apex and alveolar region are missing. Transverse section is weakly compressed, and sub-quadrate with flat venter in the posterior part of the stem region (Fig. 2E), and sub-pyriform in the anterior part of the stem region (Fig. 2D). An apical groove develops in the venter of the apex region (Figs. 2A, F). It becomes shallower and wider in the anterior part of the apex region, and turns to the flat venter of the stem region (Fig. 2F).

Remarks.—The present specimen is most similar to *Cylindroteuthis* (*Cylindroteuthis*) *puzosiana* (d'Orbigny) sensu Nikitin, 1969. Since *C.* (*C.*) *puzosiana* is a large and more robust form, *C.* (*C.*) *puzosiana* sensu Nikitin probably does not

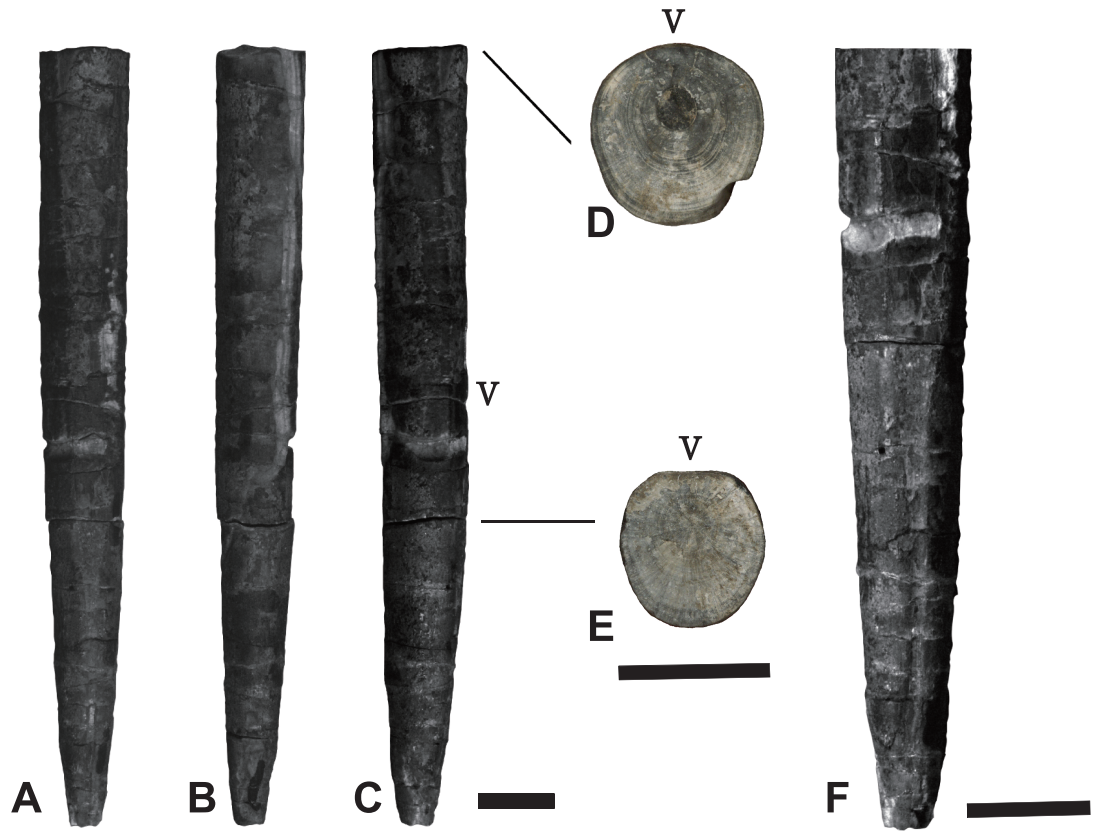

FIGURE 2. *Cylindroteuthis* (*Cylindroteuthis*) cf. *theofilaktovi* (FPDM-I-181) from the Kaizara Formation of the Kuzuryu Subgroup of the Tetori Group in Shimoyama, Kuzuryu area, Central Japan. **A,** Ventral view; **B,** Dorsal view; **C,** Right lateral view; **D–E,** Transverse sections in the anterior part of the stem region (D) and the posterior part of the stem region (E). Note that the section is sub-pyriform in the former, and weakly compressed and sub-quadrate with flat venter in the latter; **F,** Enlarged ventral view of the posterior part of the rostrum. An apical groove develops in the venter of the apex region. It becomes shallower and wider in the anterior part of the apex region, and turns to the flat venter of the stem region. V represents the ventral side. Scale = 1 cm.

belong to true *C.* (*C.*) *puzosiana*, but similar to *C.* (*C.*) *theofilaktovi* Nikitin, because it possesses a similar elongate rostrum with lateral compressed section (Dzyuba, 2004). However, revision of these Nikitin's species based on the re-examination of type materials remains to be established at this moment. Thus, in this paper, *C.* (*C.*) cf. *theofilaktovi* is used for the Shimoyama specimen.

Stratigraphical occurrences.—This species is known from the Lower Callovian *Macrocephalites macrocephalus* Zone of Central Ukraine. In Japan it occurs in the Kaizara Formation of probable Upper Bathonian–Lower Callovian age.

PALEOBIOGEOGRAPHIC IMPLICATIONS

Belemnites have been used for the Jurassic paleobiogeographic studies, and three provinces/realms were recognized in the Boreal seas, that is, Arctic, Boreal-Atlantic, and Boreal-Pacific (e.g., Saks and Nalnyaeva, 1966, 1975; Saks et al., 1971; Doyle, 1987; Challinor et al., 1992; Zakharov et al., 2003). The cylindroteuthids first appeared in the mid-Bajocian time in western Canada belonging to the Boreal-Pacific Realm (Northeast Pacific), penetrated into the Arctic Realm at the end of Bajocian and became widespread in the Boreal seas in the Callovian (Saks and Nalnyaeva, 1966, 1975, 1979; Dzyuba, 2005). Nikitin (1969, 1973) described nine species of *Cylindroteuthis* and one species of *Pachyteuthis* from the Lower Callovian of Central Ukraine. Boreal-Atlantic Realm in the Early–Middle Callovian was considered as the center of origin not only for many species of cylindroteuthids but also for some other genera and subgenera of this family: genus *Lagonibelus* with its subgenera *Lagonibelus* s. str., *Communicobelus* and *Holcobeloides*; and genus *Simobelus* (Gustomesov, 1964; Saks and Nalnyaeva, 1966; Dzyuba, 2004, 2005). The late Middle Jurassic was a time of extensive 'boreal' transgression and expansion of Boreal basin area (e.g., Shurygin et al., 2000), therefore cylindroteuthids in the Callovian spread far south into Europe. For example, *C.* (*C.*) *puzosiana*, the most widespread *Cylindroteuthis* in the Boreal-Atlantic Province occurred in the *Macrocephalites macrocephalus* Zone of Swabian Jura in Germany and Lower Oxford Clay of England, indicating the expansion of boreal elements to south in the Early Callovian time (Riegraf, 1980; Page and Doyle, 1991; Hewitt et al., 1999).

On the other hand, Middle Jurassic cylindroteuthid records in the North Pacific are scarce (Challinor et al., 1992). They were recorded in the northwestern British Columbia and Alaska on the Pacific side of North America. On the Pacific Coast of Russia, isolated finds of incomplete rostra *Cylindroteuthis* from the Callovian strata of the Tugur Bay in the Okhotsk Sea were only known records. Although Nalnyaeva (Challinor et al., 1992) assigned them to *C.* (*C.*) cf. *tonatilis* and *C.* (*C.*) cf. *strigata*, either species belongs to genus *Lagonibelus* according to the latest data (Hewitt et al., 1999; Dzyuba, 2004). However, all Tugur Bay rostra housed in the Central Siberian Geological Museum (Novosibirsk, Russia) are typical *Cylindroteuthis* and similar to our specimen.

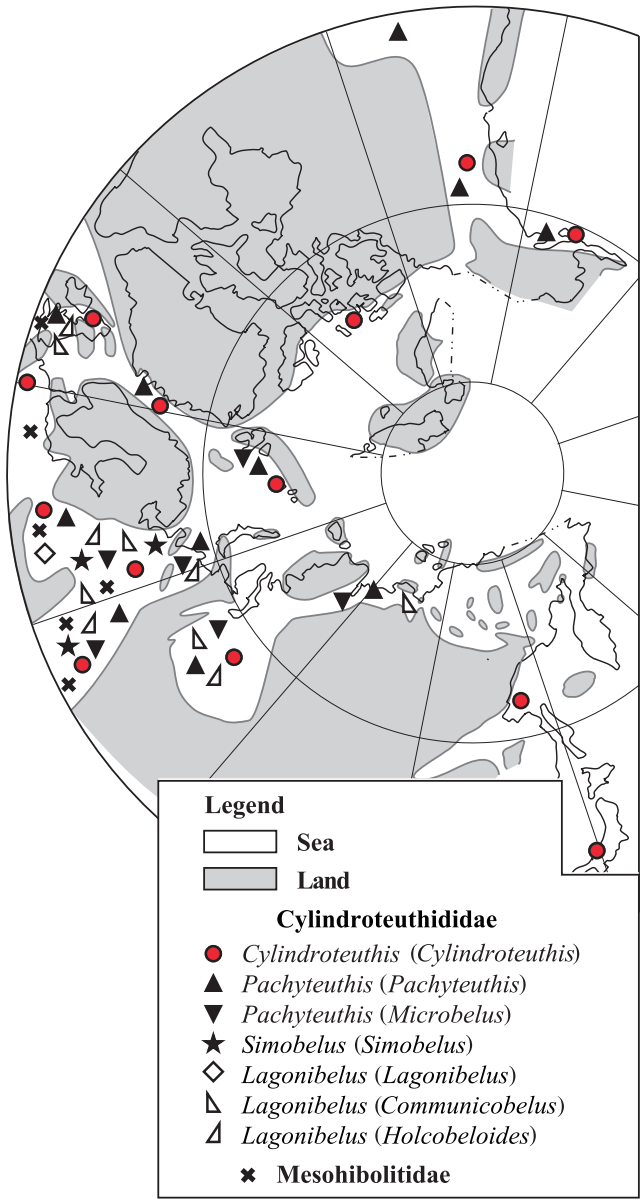

FIGURE 3. Distribution of belemnites in boreal and neighboring basins in the Callovian. Compiled from numerous sources (see Doyle, 1987; Dzyuba, 2004). Paleomap after Shurygin (2005), with some modification.

Much earlier occurrence of the cylindroteuthid, *C.* (*C.*) *confessa* (Challinor et al., 1992, pl. 132, fig. 1) has been reported from the Lower Bajocian beds with *Retroceramus clinatus* in the Bureya Basin. However, after the extraction of a rostrum from its matrix, it is recognized that putative ventral apical cylindroteuthid groove of this specimen in fact represents one of dorso-lateral apical megateuthid grooves. Hence this specimen

does not belong to the Cylindroteuthididae, but the Megateuthididae. Dzyuba, one of the authors, will publish this contribution with Nalnyaeva elsewhere. Other localities of Middle Jurassic cylindroteuthids from the Pacific coast of Russia have been also mentioned in the literatures. Tuchkov (1962) listed cylindroteuthids from the northern and northeastern coasts of the Okhotsk Sea: 1) *Cylindroteuthis* sp. from the top of the so-called "*Retroceramus* strata" of pre-Callovian age in the Koni Peninsula area; 2) *Cylindroteuthis spicularis* and *C. obelisca* from the Jurassic deposits on Penzhina Bay Coast, which was dated by belemnites as Callovian–Oxfordian; Sibiryakova in Krymholts (1972) mentioned the occurrence of *Cylindroteuthis puzosiana* from the Usmanka Formation (Upper Bathonian–Callovian) in Upper Priamurie (Russian Far East). However, since above-mentioned specimens have not been described nor figured, these nominal species need further revision.

The discovery of *Cylindroteuthis* from Central Japan provides the first and reliable evidence that this genus penetrated into the mid-latitudes of the Northwest Pacific in the Late Bathonian–Early Callovian time, further south than previously documented. *Cylindroteuthis* expanded their distribution in the Late Bathonian–Early Callovian time not only in the Boreal-Atlantic seas but also in the Boreal-Pacific seas. Furthermore, the occurrences of the same species in Central Ukraine and Central Japan imply the faunal connection between the Arctic Basin and the Northwest Pacific at that time.

The occurrence of *Cylindroteuthis* from Shimoyama also suggests that a cooler current possibly from the Arctic reached the Tetori Basin in the Late Bathonian–Early Callovian time. It should be noted that the influence of the northern current to the Tetori Basin had been already suggested from the ammonoid fauna of the Kaizara Formation by Kobayashi (1947) and Sato (1960). These authors recognized the occurrences of *Kepplerites* (*Seymourites*), which is a typical Arctic element, from the *Kepplerites japonicum* assemblage zone of the Kaizara Formation in Shimoyama (Sato and Westermann, 1991). If the belemnite specimen described herein was also collected from the same assemblage zone, the cephalopod fauna in Shimoyama strongly suggests the expansion of the Arctic elements to the mid-latitudes of the Northwest Pacific in the earliest Callovian time, almost same time with the Boreal-Atlantic Province.

Hayami (1990) suggested that several Jurassic "*Inoceramus*" species including *I. hamadae* Hayami from Shimoyama seem to belong to *Retroceramus*, a typical northern element bivalve genus. He also pointed out the similarity between the "Middle Jurassic" bivalve fauna of the Tetori Group and those of eastern Siberia (Hayami, 1961, 1990). However, since the age of the Mitarai Formation in the Shokawa area, where rich marine fauna has been described by Hayami (1959a, b, 1960) and Komatsu et al. (2001, 2002), was recently revised from the Callovian to the Berriasian (Sato et al., 2003, 2008), the details of true Middle Jurassic bivalve fauna of the Tetori Group are yet-to-be-defined. Future studies of the bivalve fauna of the Kaizara Formation would contribute to the paleobiogeographic studies of the Tetori Group.

Since occurrences of the cylindroteuthids have already been reported from the earliest Cretaceous Mitarai and Otaniyama formations of the Tetori Group in the Shokawa area, Central Japan (Kumon and Umezawa, 2001; Matsukawa et al., 2007), it could be considered that the northern current probably influenced the Tetori Basin at that time. The influence of the northern current in the Barremian Tetori Basin has been suggested based mainly on the similarity of the bivalve fauna with that of the Heilongjiang area in Northeast China, and dissimilarity with those of the Outer Zone (Pacific side) of Southwest Japan (e.g., Matsukawa et al., 1997, 2007; Matsukawa and Fukui, 2009). It is possible that the Tetori Basin was located in the place where the northern current frequently influenced from the Middle Jurassic to the Early Cretaceous time. Further studies of Late Mesozoic belemnite fauna and other marine biota from Japan could reveal their spatio-temporal changes in the Northwest Pacific.

ACKNOWLEDGMENTS

The authors would like to thank Mr. N. Handa for telling them recent advances in the ammonoid biostratigraphy of the Kaizara Formation in Shimoyama. The authors are grateful to Dr. B. N. Shurygin for consulting on Russian Far East Jurassic paleontology, to Ms. J. Anso for providing the information on the belemnite fossils from the Kaizara Formation, to Dr. T. Komatsu for discussing with the authors about the age and paleobiogeographic significances of the molluscan fauna from the Mitarai Formation of the Tetori Group in the Shokawa area. Thanks are extended to Dr. T. Sato, Dr. K. Tanabe and the editors: Dr. K. Konishi and Dr. H. Ichishima for critical review and editing works of the manuscript, to Dr. Y. Kondo, Mr. M. Kano, Dr. Y. Kakizaki and Ms. A. Yoshida for providing the authors some important references.

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* : in Russian
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*** : in Ukrainian
**** : in Japanese
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Fukui …… 福井
Kaizara …… 貝皿
Kuzuryu …… 九頭竜
Mitarai …… 御手洗
Otaniyama …… 大谷山
Shimoyama …… 下山
Shokawa …… 荘川
Tetori …… 手取