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Tohoku Univ., Sci. Rep., 2nd ser. (Geol.), vol. 45, no. 2,
p. 51~82, 3 figs., 2 tables, pls. 9–12, March 15, 1975

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ABSTRACT

Sixteen turciculid gastropod species, Recent and fossil are described from Japan. Those species are distributed among one genus *Turcicula* and the four subgenera; *Turcicula* s.s, *Bathybembix*, *Ginebis* and *Convexia*. The last mentioned subgenus is newly proposed and *Ginebis* is redefined and discussed, because of the confusion concerning its classification. Foreign and allied species of *Turcicula* are remarked based upon the nomenclature. In the classification of the species, letter formulae are proposed for the external morphological characters.

It is noteworthy that the biogeographical distribution of the group is recognized at the subgeneric level.

Prior to Pliocene, the species of the subgenus *Turcicula* had been known only from the Japan Sea side (**Japan Sea Type**), but these are found on the Pacific Ocean side of Japan from Pliocene to Recent. On the contrary, the species belonging to the subgenera, *Bathybembix*, *Ginebis* and *Convexia* were previousely known only from the Pacific Ocean side of Japan through the geological past to Recent and have been known as the **Pacific Ocean Type.** From the Recent distribution of the subgenus *Ginebis*, the Pacific Ocean side of Japan can be classified into two provinces; the northern and the southern being separated at the sea off Boso Peninsula, middle Honshu. Phylogenetically, though more data are needed, the origin of some stocks are now estimated based upon their external morphological development. Fossil turciculid gastropods might be important for geological interpretation especially of the paleogeography and the development of their tubercles are useful for ecological analysis of the sediments deposited off shore or on the continental slope.

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INTRODUCTION

Although turciculid gastropods have been accepted as indicators of the deep sea by paleontologists and neontologists, owing to the rare record and poor preservation, the geological significance of the turciculids have been even almost neglected. The systematic classification of the turciculid genera have been confused regardless of some excellent studies on the species and genera. From the different distributions, latitudinal and bathymetrical of the species and its allies or related ones, some interesting interpretations have been advocated by Shuto (1961) and Kira (1959). However, some of the fossil records have been overlooked in Japan since 1943 (Taki and Otuka, 1943), even though their records are

important and should be incorporated in interpretation of the geological and geographical significance of the group. It is expected that the paleobiogeographical interpretation of the distribution during the geological time and of the development of the external characters with age should be initiated after establishment of the systematic classification based upon the Code of International Zoological Nomenclature. Though Taki and Otuka (1943) and Rehder (1955) studied the genus *Turcicula*, some problems remained concerning the classification of the turciculid gastropoda. Fortunately many species (Fossil and Recent) of the genus *Turcicula* have been recorded from or around the Japanese Islands and many of them are now preserved in the collection of the Institute of Geology and Paleontology, Faculty of Science, Tohoku University. The present article deals with the systematic classification, morphological development, geological and geographical meaning and ecological significance of the turciculid gastropoda of Japan.

ACKNOWLEDGMENTS

The writer wishes to express his hearty thanks to Dr. Kotora Hatai, Professor Emeritus of the Tohoku University for his continuous encouragement and supervision during the present study. Deep acknowledgments are due to Professor Tamio Kotaka of the Institute of Geology and Paleontology, Faculty of Science, Tohoku University and Professor Koichiro Masuda of the Department of Geology, Miyagi College of Education for their kind suggestions on the biostratigraphy concerning the turciculid gastropods. Deep appreciation is expressed to Professor Jiro Katto of the Department of Geology, Faculty of Literature and Sciences, Kochi University for donating the specimens from the Nobori Formation and his kind guidance in the field of the eastern part of Kochi Prefecture, and to Dr. Tadashige Habe of the National Science Museum, Tokyo for the copyright of the literature. Thanks are also due to Messrs. Kimiji Kumagai and Shohei Otomo for photographic work, and Mrs. Kimiko Shibuya for typing the manuscript.

STRATIGRAPHIC DISTRIBUTION OF TURCICULID GASTROPODA

Among the distinguished 16 species of *Turcicula*, seven are extinct, two are of Eocene, one of Middle Miocene, two ranges from Late Miocene to Recent, two from Pliocene to Recent and five species are Recent forms. Geologically, *Turcicula sakhalinensis* Takeda (1953) and *Turcicula nagaoi* Noda, n.sp. are the earlist known species of the genus in Japan. The former was originally described from the Maoka Series in South Sakhalin and the Poronai Formation in eastern Hokkaido, from where Takeda (1953) reported *Yoldia laudabilis* Yokoyama, *Yolida tokunagai* Yokoyama, *Periploma besshoensis* Yokoyama, *Macoma sejugata* (Yokoyama) and many molluscan fossils. At that time, Takeda (1953) considered the Poronai Formation to be Oligocene in age and this had been supported by some paleontologists and geologists. However, Takai (1950) reported on the occurrence of the Late Eocene *Amynodon* and Asano (1962) on Eocene planktonic foraminifers from the Poronai Formation and this age was also supported by Asano and Hatai (1967) based upon the micro- and mega-fossils.

Turcicula nagaoi was also recorded from the Eocene Kattachi Formation in Kumamoto Prefecture from which many marine fossils were recorded by Yokoyama (1911), Nagao (1928) and Kuroda and Urata (1964). The two species, *Turcicula sakhalinensis* and *Turcicula nagaoi* are at present known only from the Eocene formations.

The earlist record in the early Middle Miocene is *Turcicula osawanoensis* which was described by Tsuda (1959) from the Kurosedani Formation in Toyama Prefecture in association with the Assemblage III of the Kurosedani Fauna (Tsuda, 1960). This species

is restricted to the formation. *Turcicula tsudai,* n. sp. from the Late Miocene Shiiya Formation of Niigata Prefecture occurred in association with some molluscan fossils (Yokoyama, 1928; Noda, 1969). *Turcicula crumpi* Pilsbry of Hatai and Masuda (1962) from the Late Miocene Tokigawa Formation in Saitama Prefecture is characterized by having small tuberculous rows and reticulated sculpture on the immature stage; it differs from *Turcicula crumpi* of Pilsbry (1893a). The Tokigawa species may represent an unnamed species though it is not named in this article because the specimen is somewhat deformed and the external sculpture is indistinct. There is one similar specimen from Sakhalin in the collection of the Institute of Geology and Paleontology, Faculty of Science, Tohoku University (IGPS coll. cat. no. 26311), however naming is reserved because of the unfavorable preservation. *Turcicucla argenteonitens argenteonitens* (Lischke) first described on Recent specimen by Lischke (1874) was recorded from the Late Miocene and Pliocene to Recent in Japan. This species occurs from the Late Miocene Mamurogawa Formation in Yamagata Prefecture as an oldest record, and also occurs from the Pliocene Shinzato Formation in Okinawa Prefecture, Takanabe Formation in Miyazaki Prefecture, Hijikata and Kechienji formations in Shizuoka Prefecture, Nojima and Koshiba formations in Kanagawa Prefecture, Tomioka, Kiwada and Na-arai formations in Chiba Prefecture and some Pleistocene formations around the Boso Peninsula. Recently, Shikama (1973) recorded the species from the Late Miocene Zushi Formation in Kanagawa Prefecture. Such distribution of the species shows their main life area in the southwestern part of the Kuroshio area of Japan. However, the species is not known from the Japan Sea borderland, through the geological time to Recent. *Turcicula aeola* (Watson) was named by Watson in 1878 for a Recent species, and it has been recorded from the Late Miocene Nobori Formation in Kochi Prefecture and Pliocene Nojima Formation in Kanagawa Prefecture, both in Pacific Ocean side of southwest of Japan. *Turcicula sukegawaensis* proposed in the present article on specimens from the Pliocene Sukegawa Formation in Ibaraki Prefecture occurred in association with *Mizuhopecten ibaragiensis* (Masuda), *Chlamys cosibensis* (Yokoyama) and other Pliocene fossils. But the species is, at present, only restricted to the above mentioned formation. *Turcicula convexiuscula* (Yokoyama, 1920) was originally described from the Pliocene Kamakura Beds of Yokoyama in Kanagawa Prefecture. *Turcicula convexiuscula tosana* of Shikama (1962) who proposed the subspecies from the sea off Tosa province, is synonymous with the species as stated in later pages, thus the present species ranges from the Pliocene to Recent. There are no record of it from the Japan Sea side. The fossil *Turcicula crumpi yokoyamai* Otuka may be a varietal form of the Recent *Turcicula crumpi* (Pilsbry). Ozaki (1958) first recorded the fossil *Turcicula crumpi* from the Pliocene Na-arai Formation in Chiba Prefecture and other records are the Pliocene Nojima and Koshiba formations in Kanagawa Prefecture, the Kiwada and Kakinokidai formations in Chiba Prefecture, Tenpizan Formation in Ibaraki Prefecture and Chinen Sandstone in Okinawa Prefecture. The species ranges from Pliocene to Recent. *Turcicula crumpi yokoyamai* originally described from the Pliocene Koshiba Formation in Kanagawa Prefecture (Otuka *in* Taki and Otuka, 1943) possesses four tuberculous rows, and is recorded only from the type locality. It is treated in this article as valid though it may be varietal form of *Turcicula crumpi* as described in later. *Turcicula imperialis* (Dall, 1881), the type species of the genus *Turcicula* is not known as fossil and Cossman's (1918) record of the species from the Pliocene sediments of California was based upon confusion of *Turcicula* with *Cidarina.* Four other Recent species, *Turcicula bairdi* (Dall), *Turcicula argenteonitens hirasei* Taki and Otuka, *Turcicula hataii* Noda, n. sp., and *Turcicula japonica* Dall are distributed on the Pacific Ocean side of Japan (Fig. 2).

MORPHOLOGICAL CHANGES OF THE TURCICULIDS IN GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTIONS

Turciculid gastropods are classified into four subgenera and 16 species based upon the modes of the tubercles, external sculptures, shape and sculpture of the protoconch and nature of the immature whorls. For classification of the turciculid species, the following characteristics may be convenient as key criteria. For explanation of the key to the species, the present writer made rolled traces of the external sculpture of turciculids on the surface of flattened clay. The traces of external characters were made by rotating the specimens from their apertural side towards the right on flattened clay so that all features are duplicated. By this procedure, the characteristic of external sculptures are duplicated on a plane as shown in the plates (Pls. 11–12). But specimens with deep channeled sutures give unsatisfactory traces. Those unsatisfactory traces are supplemented by letter formulae, description and illustrations. The following letter formulae are used for the classification of the species.

Capital **A** means the spiral row of distinct or rather strong tubercles on the whorl surface. When there are some rows on a whorl $\mathbf{A_1}$ $\mathbf{A_2}$ $\mathbf{A_3}$ are named adapically.

Letter **a** means indistinct or weak tuberculous row which occupy the position corresponding to **A**. When there are some rows represented by sign **a** on a whorl, $\mathbf{a_1}$ $\mathbf{a_2}$ $\mathbf{a_3}$ are used to indicate the rows from the bottom to the top on a whorl.

Letter **b** indicates the subsutural beaded row. When there are some rows on a whorl, $\mathbf{b_1b_2}$ are used for the rows from the bottom to the top.

A dot · indicates the lack of distinct tuberculous row corresponding to **A** or **a** on a whorl.

An arrow and **P**, for example, $\mathbf{A_1A_2b}\rightarrow\mathbf{P}$ indicates that the spiral sculptures shown by the letter formula can be traced back to the early stages of growth, but the arrow and $\underline{\mathbf{P}}$, for example, $\mathbf{A_1A_2b}\rightarrow\underline{\mathbf{P}}$ shows that the spiral sculptures appear in the latter stages of growth.

The top-side bar of the letter formula, for example, $\overline{\mathbf{a_1a_2b}}$ signifies that the spiral rows shown by the letter formula are forming sigmoidal fold together with each other.

The characteristic formula shown by the left side of the arrow is the external sculpture observed on the body whorl in adapical arrangement.

Based upon the proposed formula incorporated with the descriptive features of the shell, the turciculid gastropods are subdivided into four subgenera such as *Turcicula*, *Bathybembix*, *Ginebis* and *Convexia*. Each subgenera have their own characteristic elements and can be expressed by the respective formulae.

Subgenus *Turcicula* includes *Turcicula imperialis* which is the type species of genus *Turcicula* of Dall (1881). The subgenus is represented by $\mathbf{A_1A_2A_3}\rightarrow\mathbf{P}$ or $\mathbf{A_1A_2a_3}\rightarrow\mathbf{P}$. These show the well developed of three or two spiral tuberculous rows on a whorl, but lack the subsutural small beaded row. *Turcicula crumpi*, *Turcicula crumpi yokoyamai*, *Turcicula imperialis*, *Turcicula japonica*, *Turcicula osawanoensis* and *Turcicula tsudai* are belonging to this subgenus which ranges from Middle Miocene to Recent in age.

Bathybembix of Corsse (1892) is characterized by having three small tuberculous rows, sigmoidal folds combined with two or three different spiral rows represented by $\overline{\mathbf{a_1a_2a_3}}\rightarrow\mathbf{P}$ or $\overline{\mathbf{a_1a_2a_3}}\rightarrow\underline{\mathbf{P}}$ and sometimes carries a subsutural beaded row expressed by **b**. *Turcicula bairdi* and *Turcicula aeola* belong to this subgenus. The species in this subgenus are usually Recent form but some of them date back to the Late Miocene in geological age.

Ginebis proposed by Taki and Otuka in 1943 based upon *Turcicula argenteonitens argenteonitens* was not clearly defined, therefore, the confusion has been caused both in

classification and nomenclature. *Ginebis* is defined by the formula, **bAb→P** or **bAb→P**, indicating that there are the upper and lower subsutural beaded rows and a strong tuberculous row intermedially. *Turcicula argenteonitens hirasei*, *Turcicula hataii* and *Turcicula sakhalinensis* belong to the former and *Turcicula argenteonitens argenteonitens* and *Turcicula nagaoi* to the latter. The present subgenus ranges from Eocene to Recent in age.

Convexia is here proposed as a new subgenus and is represented by **b · b→P**. This formula shows that there are two subsutural beaded rows, one is at the upper subsutural and the other at the lower subsutural, but there are no distinct intermedial tuberculous row as shown by the dot mark, therefore the main part of the shell surface is smooth. *Turcicula convexiuscula* including *Turcicula convexiuscula tosana* of Shikama (1962) belongs to this subgenus. The present subgenus ranges from the Pliocene to Recent in age.

Table 1. Geological distribution of turciculid species

Specific name \ Geologic age	Eocene	Oligocene	Miocene			Pliocene	Pleisto-cene	Recent
			Early	Middle	Late			
Turcicula (Turcicula) crumpi						■	■	■
Turcicula (T.) crumpi yokoyamai						■		
Turcicula (T.) imperialis								■
Turcicula (T.) japonica								■
Turcicula (T.) osawanoensis				■				
Turcicula (T.) tsudai					■			
Turcicula (Bathybembix) aeola					■	■	═	■
Turcicula (B.) bairdi								■
Turcicula (Ginebis) argenteonitens s.s					■	■	■	■
Turcicula (G.) argenteonitens hirasei								■
Turcicula (G.) hataii								■
Turcicula (G.) nagaoi	■							
Turcicula (G.) sakhalinensis	■							
Turcicula (G.) sukegawaense						■		
Turcicula (Convexia) convexiuscula						■	═	■
Turcicula sp.					■	■		

The geological records of the species belonging to the genus (Table 1) show that from the Pliocene to Recent abundant species appear, whereas those of pre-Pliocene age are rather few in number of species and individuals.

The geographical distribution of the turciculid species based upon the fossil and Recent records (Figs. 1～2) shows some interesting features biogeographically.

Turcicula osawanoensis of Middle Miocene age in association with rather warm water mega-fossils as stated by Oyama (1950) and Tsuda (1959, 1960) is the oldest record in Miocene for the genus from the Japan Sea borderland. *Turcicula tsudai* associated with rather temperate water forms of molluscs (Yokoyama, 1928; Hayasaka, 1940; Noda, 1969) from the Late Miocene Shiiya Formation in Niigata Prefecture is another species from the Japan Sea borderland. They belong to subgenus *Turcicula*, and are only forms distributed in the Japan Sea borderland (Figs. 1～2). On the contrary, the species belonging to *Bathybembix*, *Ginebis* and *Convexia* are from the Pacific Ocean side of Japan. This different pattern in distibution permit to call the former the *Japan Sea Type* and the latter the *Pacific Ocean Type*. Some species of *Pacific Ocean Type* have been recorded from western North America, but none from the Japan Sea borderland. The species of *Japan Sea Type* during Pliocene time have become mixed with those of *Pacific Ocean Type* along the Pacific Ocean side of Japan (Fig. 1). It is interesting and important to know that the seas of both sides of the Japanese Islands are likely to have been connected with each other to permit mixing of the different types during the Pliocene time. It is also notewor-

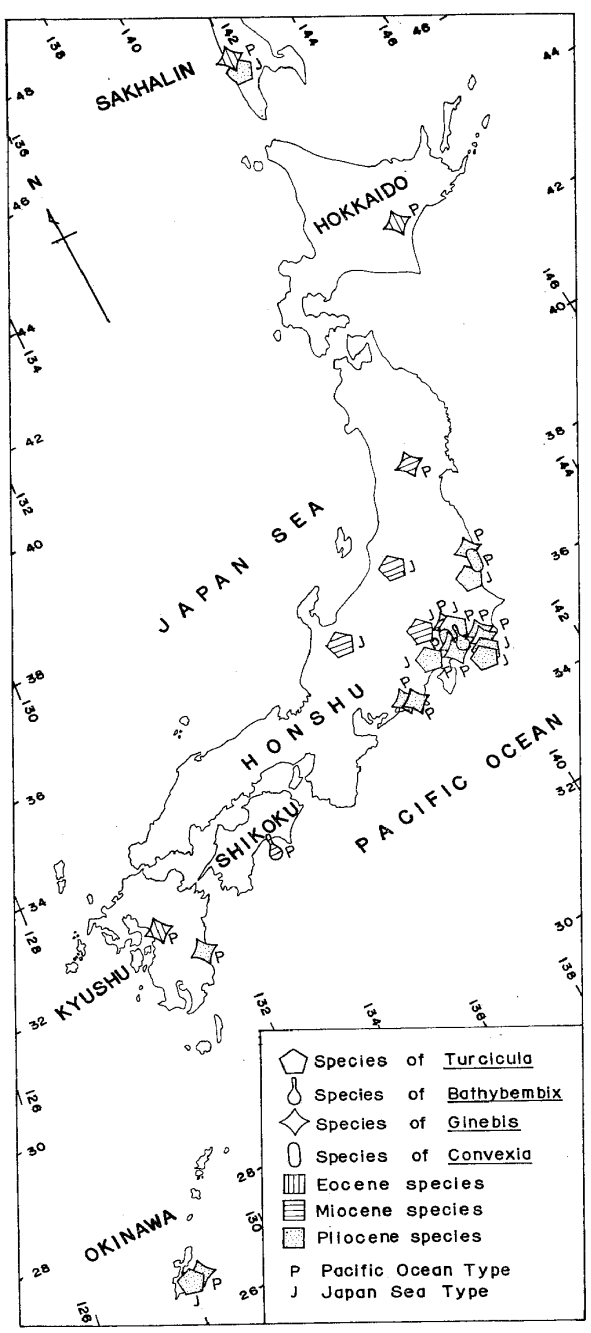

Fig. 1.

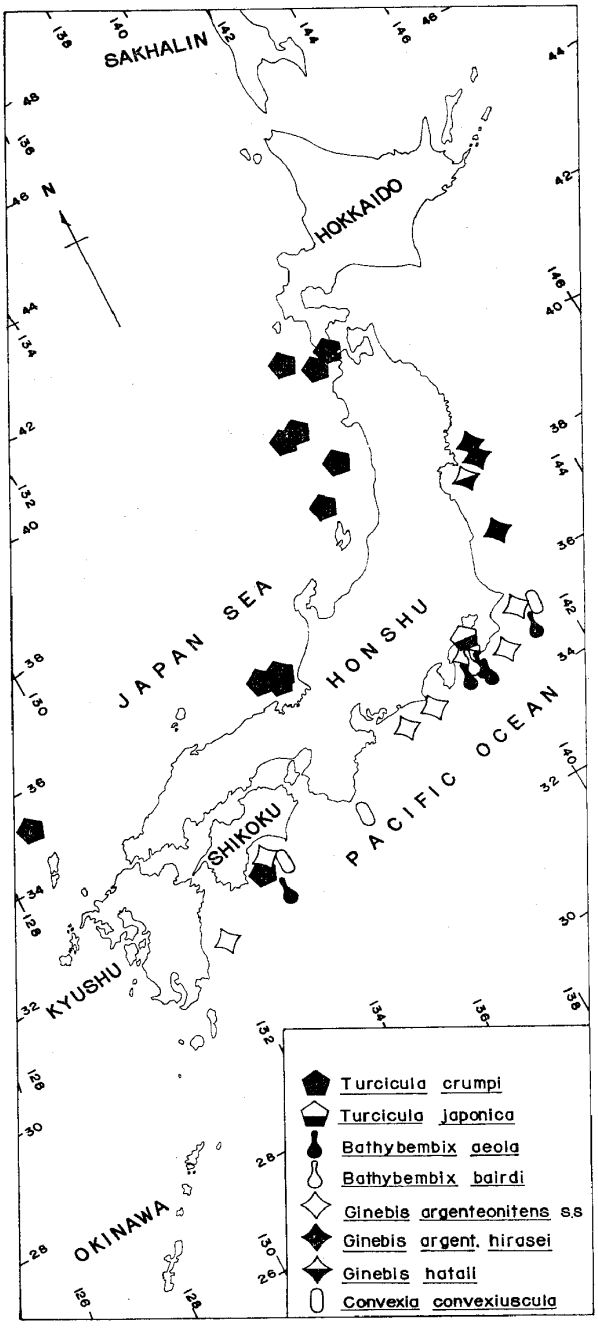

Fig. 2.

Fig. 1. Geographic distribution of the fossil turciculid species in Japan as subgeneric rank.
Fig. 2. Geographic distribution of the Recent turciculid species in Japan.

thy that the species with conspicuous or distinct tuberculous rows on the surface are apparently restricted in distribution to the Japan Sea side or Recent Sea of Japan; and the species having relatively convex shell surface, smooth sculpture or discontinuous development of tuberculous rows on the surface are habitants of the sea of the Pacific Ocean side of Japan.

Along the Pacific Ocean side of Japan, there are some characteristic patterns of turciculid distribution. For example, *Turcicula argenteonitens argenteonitens* indicated by

bAb→P is distributed mainly in the sea of southwest and does not reach north of the Boso Peninsula where another type *Turcicula argenteonitens hirasei* shown by **bAb→P** is mainly distributed. The non-overlap in distribution as shown above had been already mentioned by Kira (1959) and Shuto (1961). Another example of contrasting distribution between northern and southern types is known in Eocene. Takeda (1953) described *Turcicula sakhalinensis* from the Eocene Poronai Formation in eastern Hokkaido and Sakhalin, and Nagao (1928) reported *Turcicula* sp. (named *Turcicula nagaoi* in the present article) from the Eocene Kattachi Formation in Kumamoto Prefecture. The former species is represented by formula **bAb→P** and the latter by **bAb→P**. Both species are remote from one another in distribution (Fig. 1), but are characterized by the similar formula. Once Kira (1959) suggested that the trend in evolution of *Turcicula* was started from the primitive species with smooth external surface to the advanced one with some distinct tuberculous row(s). According to Kira's view on the phylogenetic trend of *Turcicula*, *Turcicula convexiuscula* may be ancestral to *Turcicula argenteonitens*, because the latter has distinct tuberculous row on the adult stage but not in the immature one, while the former has smooth external surface abapical. As already stated (Noda, 1969), there are some species having distinct tuberculous sculpture prior to Pliocene record of *Turcicula convexiuscula* stated by Kira (1959). Although Kira expressed his view on the evolution of the genus, the following data should be added to his view in order to explain the morphological development and evolutional trend of the turciculid gastropods. The external morphology has changed from the Eocene to Recent and shows the certain phylogenetical trend. For example, *Ginebis* first appeared and extended its distribution in Japan during the Eocene age. The specimens of that subgenus develop their external tuberculous row from the middle stage of its growth and it becomes stronger with growth. It can be assumed that the species with smooth shell surface may represent the primitive form, and the development of external tuberculous row(s) is a feature of the advanced form as can be observed the different stages of growth of the same specimen. Comparative studies point out that *Ginebis* may be related to *Turcicula*. Both subgenera *Ginebis* and *Turcicula* have their own provinces in geographical distribution through the geological age. *Bathybembix* and *Convexia* are somewhat different in the mode of development of the tubercles compared with *Turcicula* and *Ginebis* mentioned above. *Bathybembix* is characterized by longitudinal folds as shown by formula $\overline{\mathbf{a_1a_2a_3}}\rightarrow\mathbf{P}$ or $\mathbf{a_1a_2a_3}\rightarrow\mathbf{P}$, and *Convexia* has rather smooth external surface as shown by formula **b · b→P**. In applying the similar phylogenetical consideration which already discussed in earlier lines on *Ginebis* and *Turcicula*, it can be expected that there might have been ancestral forms in earlier Eocene time, which had more primitive sculptural characters than *Bathybembix* and *Convexia*.

From the records of the Recent species (Fig. 3), it is noteworthy that the turciculid species are generally known to be deep water forms. Among them, the species (living) belonging to the subgenera *Bathybembix* and *Convexia* are usually recorded from deeper water compared with the species of subgenera *Ginebis* and *Turcicula*. The latter subgenera are defined by having distinct tuberculous rows as shown by formula $\mathbf{A_1A_2A_3}$ or **bAb** and small size in general (Table 2). The former subgenera have rather smooth or not strong sculptures on the external surface, and are generally larger in size compared with the latter (Table 2). As stated above, the *Turcicula* species with smooth or indistinct tuberculous sculptures might be said to represent the primitive form phylogenetically, whereas the advanced forms are provided with distinct tuberculous rows. The primitive forms are generally of deep water in the Pacific Ocean off Japan and the advanced forms inhabit less deep water in the Sea of Japan.

It is interesting to note that *Turcicula nagaoi* was described from the Eocene Kattachi

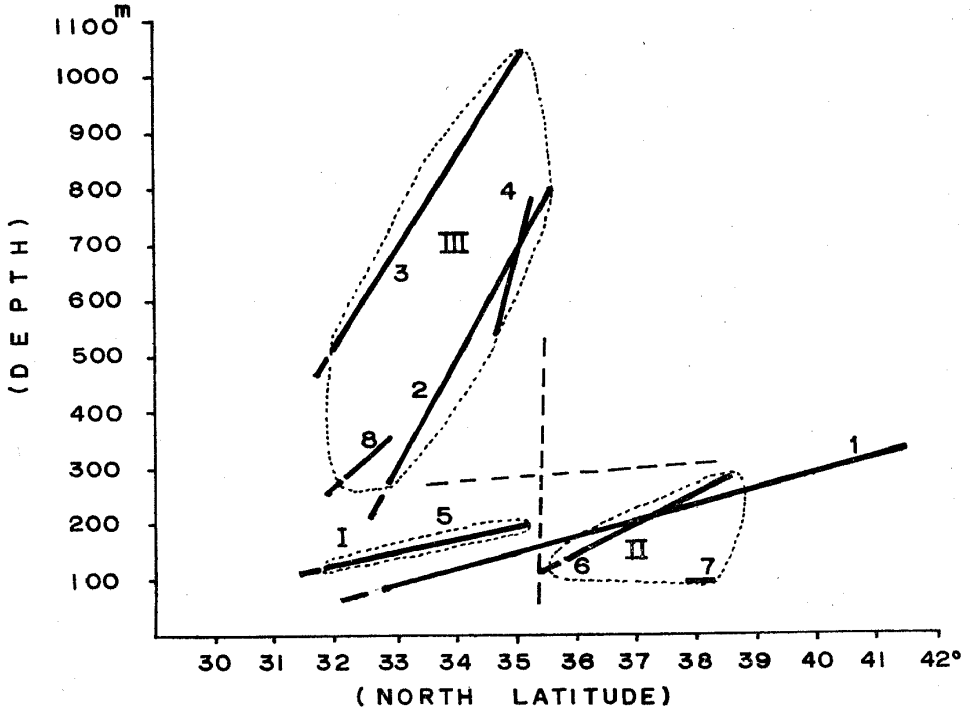

Fig. 3. Bathymetrical and latitudinal distribution of Recent turciculid species in Japan. 1 *Turcicula* (*Turcicula*) *crumpi*, 2 *T.* (*Turcicula*) *japonica*, 3 *T.* (*Bathybembix*) *aeola*, 4 *T.* (*Bathybembix*) *bairdi*, 5 *T.* (*Ginebis*) *argenteonitens argenteonitens*, 6 *T.* (*Ginebis*) *argenteonitens hirasei*, 7 *T.* (*Ginebis*) *hataii*, 8 *T.* (*Convexia*) *convexiuscula*, I Southern forms of the Pacific Ocean Type, II Northern forms of the Pacific Ocean Type, III Archibenthal forms of the Pacific Ocean Type, 1 Mainly distributed on the Japan Sea borderland as the Japan Sea Type. Bathymetrical and latitudinal gapes are shown by dashed lines.

Table 2. Shell size of turciculid species (in cm).

Specific name	Maximum shell height	Maximum shell diameter
Turcicula (Turcicula) crumpi	31*	25
Turcicula (T.) crumpi yokoyamai	33	27
Turcicula (T.) imperialis	54	48
Turcicula (T.) japonica	28*	17*
Turcicula (T.) osawanoensis	22	22
Turcicula (T.) tsudai	29	27
Turcicula (Bathybembix) aeola	40	36
Turcicula (B.) bairdi	50*	42*
Turcicula (Ginebis) argenteonitens s.s.	48	35
Turcicula (G.) argenteonitens hirasei	59	46
Turcicula (G.) hataii	15*	12*
Turcicula (G.) nagaoi	37*	-
Turcicula (G.) sakhalinensis	49*	45*
Turcicula (G.) sukegawaense	45	33
Turcicula (Convexia) convexiuscula	28	19*
Turcicula sp.	22*	21*

Note * cited from the original descriptions

Formation from where Kuroda and Urata (1964) described *Lima nishiyamai* (Yokoyama), *Crassatellites nipponensis* Yokoyama, *Venericarida nipponica* (Yokoyama), *Perotrochus eocenicus* Kuroda and Urata, *Pseudoperisolax yokoyamai* Suzuki and Ito and others. They considered that the Kattachi Fauna distributed in Omuta City, southern part of Fukuoka

Prefecture may have inhabited a subneritic or bathyneritic environment. In addition, the occurrence of *Aturina zigzag* Yokoyama and *Aturina nagaoi* Kobayashi and other molluscan fossils (Yokoyama, 1911; Nagao, 1928; Kobayashi, 1956; Kuroda and Urata, 1964), supports that the Kattachi Formation was most probably deposited under the influence of warm or subtropical sea water. From the occurrence of the Middle Miocene species *Turcicula osawanoensis* (Tsuda, 1959) from the Kurosedani Formation in Toyama Prefecture, central part of Japan Sea borderland in association with many marine molluscs and larger foraminifers (Tsuda, 1959, 1960; Kobayashi and Masatani, 1955), it is inferred that the species lived in the outer neritic zone under the influence of rather warm or subtropical sea. As stated above the available paleontological data point out that during the Eocene or Middle Miocene, the turciculid gastropod species inhabited a sea of moderate depth under the influence of a warm or subtropical condition. The turciculid gastropods gradually changed their mode of life or habitat to become adapted to a rather bathyal part of the temperate to rather cool sea water region at least during the Pliocene to Recent as shown by the distribution of the associated molluscan fauna.

In other words, it can be said that the development in external characters and speciation of the turciculid gastropods was progressed with the change of thermal condition and adaptation to the changing the physicochemical one of the sea water from the Eocene to Recent in time.

REMARKS ON THE TURCICULID SPECIES FROM FOREIGN COUNTRIES

The turciculid gastropod species and subspecies, Recent and fossil seem to be concentrated to the Japanese Neogene or seas surrounding Japan (Figs. 1~2). However, there are some species recorded from foreign countries as mentioned below.

In 1924, Krumbeck recorded as new species, *Trochus* (*Turcicula*) *timorensis* and *Trochus* (*Turcicula*) *subtimorensis* from the Triassic formation in Timor. Both of these species are characterized by narrow longitudinal folds ending in nodules subsuturally somewhat like spiral cords, their shell are highly spired with deeply channeled suture lines and narrow basal parts. Those characters are different from the diagnostic features of *Turcicula* and rather resembles the genus *Eunemopsis* Kittle, 1891 or *Riselloides* Cossmann, 1909 both of the Family Ameberleydae Wenz, 1938 (=Eucylidae Koken, 1896).

Turcicula costellata Koken (1897) is another Triassic species from Hallstatt described under the generie name of *Turcicula*, but the described and illustrated characters of the species differ from the external features of the turciculid species, thus it may belong to some other genus. It is clear that the re-examination of specimens necessory for classification.

Ravn (1933) described three new species which he stated to be allied to certain turciculids, namely *Monodonta* (*Danielia*) *fexensis*, *Monodonta* (*Danielia*) *quadricordata*, *Monodonta* (*Danielia*) *fenestrata* from the Danian formation in Denmark. These three species resemble certain turciculid species in lateral view, but since they are characterized by possessing distinct longitudinal folds, they may belong to some other group.

Turcicula turbonata described from the Oligocene deposits of North America by Clark in 1932 and subsequently by Addicott *et al.* (1971) and Kanno (1971) under the name of *Bathybembix turbonata*. Kanno (1971) described *Bathybembix jonesi* as a new species from the Oligocene Poul Creek Formation in Alaska. Both species described from the Oligocene Poul Creek Formation are characterized by its rather low, wide spiral angle, smooth external surface and somewhat angular periphery, and base being rather flat. Though the shell form of these two species resembles *Turcicula washingtoniana* Dall mentioned below except the external sculptures, there are no similar species among the

Japanese turciculids in shell form and external sculpture. From the Paleogene formations of North America, Dall (1909) described *Turcicula columbiana* and *Turcicula washingtoniana*, both of which are characterized by external sculptures as stated below. The former species (Dall, 1909, p. 100, pl. 3, figs. 2, 10, Eocene of Rock Creek, Columbia County, Oregon) in being characterized by a cardinal ridge at the periphery distinguished it from the Japanese *Turcicula* species. The latter species (Dall, 1909, p. 99–100, pl. 12, figs. 1–2, pl. 13, fig. 4, Oligocene of Restoration Point, Puget Sound, Washington) is characterized by the distinct elevated ridge at the periphery. These two species with distinct spiral ridge along the periphery are so different from the known turciculids, and a new subgeneric name seems appropriate.

Durham (1944) described *Turcicula arnoldi* as a new species from the Oligocene Marrowstone Shale of North America. That species resembles *Turcicula sanctacruzana* (Arnold) as already stated by Durham (1944) and may belong to *Turcicula* s.s. in the present sense. *Turcicula sanctacruzana* described from the Oligocene San Lorenzo Formation in North America by Arnold (1908) is characterized by two tuberculous rows and 6–7 spiral cords on the base. Among those, two species of *Turcicula arnoldi* and *Turcicula sanctacruzana* have similar tuberculous rows, and some Japanese turciculid species of subgenus *Turcicula* such as *Turcicula osawanoensis* (Middle Miocene) and *Turcicula crumpi* (Pliocene to Recent) have also similar characters with the American Paleogene species. American Recent species *Turcicula imperialis* Dall which was illustrated by Rehder in 1955 also resembles *Turcicula arnoldi*. Accordingly, both Paleogene species of America are very important for the systematic classification and paleogeographical interpretation among the turciculid species on both Japan and American sides of Pacific Ocean.

Turcicula bairdi is known from California and Japan (Fig. 2). *Turcicula macdonardi* Dall (1889b) from off Mancta, Ecuador resembles *Turcicula sukegawaense* in the weak tuberculous spiral row intermedially and high trochoid shell, but is not keeled on the later stage of growth. From the external sculpture, *Turcicula macdonardi* is said to have similar character with those of subgenus *Ginebis* in the present sense.

Turcicula imperialis originally reported from northeast Cuba has been recorded from off Pointe de Feu, St. Vincent, British West Indies (Rehder, 1955), and the species has never recorded as a fossil form. Although Cossmann (1918) described *Margarita* (*Turcicula*) *imperialis* from the Pliocene of California and Sicily, his *imperialis* could be allocated to *Cidarina cidaris*.

From the above stated records, the genus *Turcicula* appeared in the Eocene of Japan and America and ranges up to Recent. The records from the Triassic (Krumbeck, 1924, and Koken, 1897) and Danian (Ravn, 1933) should be questionable as they probably belong to some other family and genus.

There are some species to be in need of re-examination as; *Bathybembix* sp. and *Bathybembix* cf. *convexiuscula* both described from the Shimajiri Group in Okinawa-jima by MacNeil in 1960 because of their specimens have different external sculptures among the turciculid species treated here and unfavorable preservations.

Turcicula miranda, *Turcicula aliciae*, *Turcicula normani* all described from the Azores by Dautzenberg and Fischer (1898) are still reserved under the need of re-examination for the lack of literature at hand. At least the last mentioned species may belong to genus *Calliostoma* as pointed out by Rehder (1955).

SYSTEMATIC DESCRIPTION

Family Trochidae Rafinesque, 1815
Subfamily Monodontinae Cossmann, 1916
Genus *Turcicula* Dall, 1881

Type species: *Margarita imperialis* Dall, 1881, Recent.
Turcicula Dall, 1881, vol. 9, no. 2, p. 42–43.
Turcicula Dall, Dall, 1909, 59, p. 98.
Turcicula Dall, Oldroyd, 1927, p. 190–191.
Turcicula Dall, Thiele, 1931, Bd. 1, p. 47.
Turcicula Dall, Wenz, 1938, Teil 1, p. 272.
Turcicula Dall, Taki and Otuka, 1943, vol. 1, no. 3, p. 93–98.
Turcicula Dall, Rehder, 1955, vol. 31, pts. 5–6, p. 223.
Turcicula Dall, Knight *et al.*, *in* Moore, 1960, Part N, p. N 256.

Remarks: *Turcicula* was first proposed by Dall (1881) as a subgenus for the group of trochoid forms characterized with nodule or tuberculous row(s) on the whorls and fine faint scraches or lines, swollen body whorl and closed umbilicus. *Turcicula* was subsequently raised by Dall (1909) to generic rank and into it *Bembix* Watson (1879) and *Bathybembix* Crosse (1892) were placed as its synonyms. *Bathybembix* was proposed by Crosse (1892) for *Bembix* Watson (1897) (type species, *B. aeola* Watson), which was preoccupied by Konick (1844) and also Fabricius (1775, for a hymenopterid insect). Dall (1909) included *Bathybembix* in *Turcicula* based upon that Schepman's description and figure of *Bathybembix aeola* is, without doubt, a typical *Turcicula*, and in the foot note Dall (1909) stated

> "the correctness of Schepman's view has been confirmed by the kindness of E.A. Smith assistant in the British Museum of Natural History, who compared specimens for me with the type of *aeola* and finds them to 'agree admirable' in all essentials".

Subsequently, Rehder (1955) examined an adult specimen and the type specimen (*Turcicula imperialis*) of genus *Turcicula* and concluded that *Bathybembix* is a distinct genus, although probably related to *Turcicula*. Rehder (1955) also considered that the subgenus *Ginebis* which was proposed by Taki and Oyama (1943) though the definition is incomplete so far as the International Code of Zoological Nomenclature is concerned, is valid. In 1960, Knight *et al.* (*in* Moore, 1960) treated *Turcicula* and *Bathybembix* as valid genera and *Ginebis* as a subgenus of *Bathybembix*. This procedure is accepted by the writer, partly. At present, the turciculid species can be classified into four subgenera.

Subgenus *Turcicula* s.s.

Type species: *Margarita imperialis* Dall, 1881 (Original designation).

Turcicula (*Turcicula*) *crumpi* (Pilsbry, 1893)

Pl. 9, figs. 7, 8, 10, 13, Pl. 10, figs. 5, 19, 20, Pl. 12, figs. 3, 4, 5

Calliostoma crumpii Pilsbry, 1893a, p. 105, pl. 2, fig. 3.
Bathybemix crumpii Pilsbry, Pilsbry, 1893b, p. 133, pl. 2, fig. 3.
Bathybembix crumpii Pilsbry, Pilsbry, 1895, p. 97, pl. 11, fig. 4.
Turcicula crumpii (Pilsbry), Taki and Otuka, 1943, p. 101–103, pl. 1, fig. 2.
Lischkeia crumpi (Pilsbry), Taki in Hirase, 1954, pl. 69, fig. 7.
Turcicula (*Ginebis*) *crumpii* (Pilsbry), Kira, 1956, pl. 6, fig. 3.
Turcicula crumpii (Pilsbry), Ozaki, 1958, p. 139–140, pl. 8, fig. 18.
Bathybembix (*Ginebis*) *crumpii* (Pilsbry), Taki *in* Okada and Taki, 1960, p. 193, pl. 84, fig. 22.

Bathybembix (Ginebis) crumpii (Pilsbry), Habe in Okada, 1965, p. 27, fig. 67.
Turcicula (Ginebis) crumpii (Pilsbry), Kira, 1963, p. 12, pl. 6, fig. 3.
Ginebis crumpi (Pilsbry), Kuroda, Habe and Oyama, 1971, p. 31, pl. 9, fig. 9, p. 45.

The present species was originally described by Pilsbry (1893a) as:–

"Shell closely resembling *C. argenteonitens* Lischke (Manual of Conchology, XI, pl. 63, fig. 32) in contour, color and texture. Differing from that species in the more convex whorls of the spire, the deeply channeled suture, and in sculpture. The body-whorl is rounded, and has a girdle of prominent tubercles at the periphery; above this is another similar girdle of tubercles, occupying the place of the supraperipheral series of knobs in *C. argenteonitens*. The deep, channelled suture is bordered by a necklace of beads. The base has six encircling carinae, like those of *argenteonitens* but more distinctly beaded. The whorls of the spire show the two prominent series of tubercles, and the subsutural row; the beads of the latter sometimes duplicated. Aperture round, oblique, the outer lip slightly expanded; columella and parietal lips regularly arcuate, pearly. Interior silvery, with the reflection of opal. Alt. 31, diam. 26, oblique alt. of aperture 17 mil. Habitat Japan."

The present species is characterized by deeply channeled sutures, and two or three prominent rows of tubercles. The tuberculous row at the middle part of whorl is most prominent and 14–15 in number and the lower one is somewhat smaller than the former. The two lower rows are somewhat like twins, being paired and parallel. The upper one is subsutural and each tubercle is small and number more than the two lower rows; they are distinct on the penultimate and body whorls. Protoconch smooth and immature whorls sculptured with three rows and longitudinal striations which are chained as like as cancelated sculpture. Shell surface with weak sigmoidal wrinkle-like striations. Base of shell with 6 or 5 narrowly elevated spiral cords with small tubercles near the aperture. The formula is $\mathbf{A_1A_2a_3 \rightarrow P.}$

The present species resembles *Turcicula hataii*, n. sp. in the shell form and surface sculpture of the immature stage but the former differs from the latter in having prominent paired rows of tubercles without a subsutural row of beads, and deeply channeled suture lines. In the description of *Lischkeia osawanoensis* as a new species from the Middle Miocene Kurosedani Formation, Tsuda (1959) compared his new species with *crumpi* but the latter differs from the Kurosedani species in having rows of prominent tubercles and deeply channeled suture lines. *Turcicula crumpi yokoyamai* proposed by Otuka (1943 *in* Taki and Otuka, 1943) may be one of the variatal forms of *Turcicula crumpi* but is here treated as a valid subspecies because it can not be re-examined at present. According to Otuka (1943 *in* Taki and Otuka), *Turcicula crumpi yokoyamai* is characterized by possessing four spiral rows of tubercles but among the specimens *Turcicula crumpi*, some show small tubercles on the upper basal cord and some show three or four rows of tubercles.

Type locality: Japan, precise locality not given.

Recorded formation: Koshiba Formation in Kanagawa Prefecture (Taki and Otuka, 1943); Na-arai Formation in Chiba Prefecture (Ozaki, 1958).

Geological distribution: Kiyokawa (IGPS no. 24051), Sanuki (IGPS no. 18488), Kurotaki (IGPS no. 24524), Kiwada (IGPS no. 24361) and Kakinokidai (IGPS no. 43122) formations all in Chiba Prefecture; Koshiba Formation in Kanagawa Prefecture (IGPS nos. 17849, 17854, 24903); Tenpizan Formation in Ibaraki Prefecture (IGPS no. 15781), Chinen Sand in Okinawa Prefecture (IGPS no. 91759).

Recent distribution: Korean Strait (IGPS no. 55344, 160 m, 250 m); off Sado Island 150–205 m, off Tobi-shima 338 m (Niino, 1935); off Mogami Bank 140 m (Niino, 1952); off Tappi-zaki 123 m (Niino, 1934); off Kyuroku-jima 100–150 m (Nomura and Hatai, 1940); Wakasa Bay 123–271 m (Niino, 1950; Nomura and Niino, 1940); off Omae-zaki 400 m, Osumi-ariake Bay 150 m, off Shimoda 400 m, off Kii Peninsula,

Tosa Bay (Taki and Otuka, 1943); off Daito-zaki 400 m (Nomura, 1940); Honshu to Kyushu 30–300 m (Kira, 1959; Habe *in* Uchida, 1960); Honshu, Aomori and Kochi 100–200 m (Taki *in* Okada and Taki, 1960).

Geological range: Pliocene to Recent.

Turcicula (*Turcicula*) *crumpi yokoyamai* Otuka, 1943

Pl. 10, figs. 1, 2

Bembix crumpii, Yokoyama, 1920, p. 90, pl. 5, figs. 27–28.
Turcicula crumpi yokoyamai Otuka *in* Taki and Otuka, 1943, p. 103, figs. 5a-b.
Turcicula crumpi yokoyamai Otuka, Taki and Oyama, 1954, pl. 6, figs. 27–28, (reproduced from Yokoyama, 1920).

The present species was first named by Otuka (1943, *in* Taki and Otuka) for the specimen illustrated from the Kamakura and Kanazawa beds in Kanagawa Prefecture by Yokoyama (1920) as *Bembix crumpii*. It was given the following description:–

"Only fragments, but recognized by a thin shell with two coarse rows of distant spined tubercles with another row of much smaller tubercles close to the upper suture. The base has either distinct crenulated spiral cords or rows of tubercles linked by threads. The specimens are somewhat smaller than that figured by Pilsbry."

Otuka (1943 *in* Taki and Otuka) recognized four tuberculous rows on the body whorl. However, according to the description and illustration of Yokoyama (1920), the specimen seems to have features similar with *Turcicula crumpi* originally described by Pilsbry (1893a). At the present time, the writer hesitates to combine this species with *Turcicula crumpi* because some specimens carry reticulate sculpture and distinct development of spiral threads with small tubercles on the upper part of base. It seems to have four tuberculous rows.

Type locality: Kewaizaka, Kamakura City, Kanagawa Prefecture, Kamakura zone (=Urago Formation), Pliocene.

Recorded formation: Kamakura zone (=Urago Formation), Kanazawa zone (Ofuna Formation) both in Kanagawa Prefecture; Hara Formation in Yamanashi Prefecture.

Geological age: Pliocene.

Turcicula (*Turcicula*) *imperialis* (Dall, 1881)

Pl. 10, figs. 8, 21

Margarita (*Turcicula*) *imperialis* Dall, 1881, p. 42–43.
Margarita (*Turcicula*) *imperialis* Dall, Dall, 1889a, p. 376, pl. 22, figs. 1, 1a.
Solariela (*Turcicula*) *imperialis* Dall, Pilsbry, 1889, p. 330, pl. 49, figs. 29–30.
Lischkeia (*Turcicula*) *imperialis* (Dall), Wenz, 1938, p. 272, fig. 567.
Turcicula imperialis Dall, Rehder, 1955, p. 223–225, pl. 12, figs. 1–9.
Turcicula imperialis Dall, Knight *et al.*, *in* Moore, 1960, p. N. 256, figs. 163–12a–b.

The present species was originally described by Dall (1881) under the name of *Margarita* (*Turcicula*) *imperialis* from the Recent sea of off Cuba, Pourtales in 200 fathoms depth.

He gave the following description:–

"Shell with five (?) whorls, globosely conical, white, extremely thin; umbilicus reduced to a mere chink under the thin callus of the upper part of the pillar lip. Mouth rounded rectangular, pillar somewhat concave, margins all thin; base flattened convex, with seven revolving ribs, the outermost of which is just within the periphery, crossed by radiating lines of growth, regular and very fine, but raised into low, very sharp lamellae, which pass over the periphery on to the upper surface of the

whorl; the last is provided with two strong revolving ribs, one of which forms the periphery, while the other lies a little less than half-way from the first toward the suture; two indistinct threads run in the vicinity of the suture; on the revolving ribs above mentioned there are regularly disposed sharp rough tubercles (seventeen on the last whorl), most prominent on the middle carina; the above mentioned lamellae are arranged with a regular irregularity (which gives a shagreened appearence to the surface) between the carinae, and are still coarser and more elevated over the threads near the suture, forming there a double row of scales partly obscuring the suture, which is nevertheless rather deep. Alt. of last whorl, 10.0, Lat. 13.0, Alt of apperture 5.5, Lat. of same 6.25 mm. Off Cuba, Pourtalès in 200 fms."

The present species is the type species of the genus *Turcicula* (Dall, 1881). Since Dall (1881) described the present species and proposed the subgeneric name *Turcicula*, many malacologists have questioned the subgeneric category but Rehder (1955) re-studied *Turcicula*. Subsequently he concluded that *Turcicula imperialis* is valid. At that time he pointed out that *Bathybembix* as a genus related to *Turcicula*. This opinion was supported by MacNeil (1960) and Knight *et al.* (*in* Moore, 1960). The present species is characterized by possessing two rows of conspicuous tubercles and subsutural small beaded rows above and below ($\mathbf{bA_1A_2b}$ as formula).

The present species differs from *Turcicula crumpi* in having two tuberculous rows and subsutural small beaded rows but the latter has three conspicuous tuberculous rows without subsutural beaded rows.

Up to date the present species has been known only from off Cuba (type locality) and off Habana as Recent. The present description and discussion here are such reasons that *Turcicula imperialis* is a type species of the genus and allied species as *Turcicula crumpi* and *Turcicula japonica* are recorded from Japan.

Type locality: Off Cuba, 200 fathoms, Recent.

Recent distribution: Off Cuba 200 fathoms (Dall, 1881); off Pointe de Feu, St. Vincent 30–50 fathoms (Rehder, 1955); off Habana, Cuba 182 fathoms (Rehder, 1955).

Turcicula (*Turcicula*) *japonica* Dall, 1925

Pl. 10, fig. 7

Turcicula japonica Dall, 1925, p. 29, pl. 36, fig. 11.
Turcicula japonica Dall, Taki and Otuka, 1943, p. 103–104, fig. 6.
Bathybembix japonica Dall, Habe, 1961, p. 10, pl. 5, fig. 18.
Ginebis japonica (Dall), Kuroda, Habe and Oyama, 1971, p. 31, pl. 9, fig. 6, p. 46.

The present species was originally described upon the specimens from the Uraga Strait by Dall in 1925 with the following descreption:

"Shell small for the genus; as only dead specimens were obtained, the original color is uncertain; they are now grayish white; apex acute, the nucleus eroded, but there are about 6 subsequent whorls; suture distinct, minutely crenulated; axial sculpture of minutely imbricate sharp incremental lines over the whole surface; above the periphery there are 3 spiral rows of subspinose nodules; on the base behind the pillar are 4 spiral rows of minute nodules and 2 minor threads immediately behind the pillar; aperture subcircular, pearly; lips simple, pillar convexly arcuate, smooth; base impervious, height of shell, 28; diameter, 17 mm. U.S. Nat. Mus. Cat. no. 205752."

The present species was dredged by the U.S. Bureau of Fisheries steamer Albatross, at station 5093 in the Uraga Strait in 302 fathoms, sand bottom, bottom temperature 43.9°F according to Dall (1925). Since Dall (1925) described the species, Taki and Otuka (1943) re-described the species using Dall's illustration. The present species is characterized by having three spiral rows of knob-like tubercles and deeply channeled suture lines.

It resembles *Turcicula tsudai*, n. sp., from the Late Miocene Shiiya Formation in Niigata Prefecture in having rather strong spiral tuberculous rows in three arrangement on a whorl but the former differs from the latter which has more numerous knobs on a spiral and no sub-sutural beaded sculpture. *Turcicula sakhalinensis* Takeda from the Eocene Poronai Formation in South Sakhalin and Hokkaido resembles the present species in having similar sculpture on the body whorl but the latter has only a single spiral row whereas the latter has strong three rows of tuberculous knobs. *Turcicula crumpi* rather resembles the present species in having $A_1A_2A_3$ formula but the latter has more strong knob-like tubercles in three rows.

Type locality: — Uraga Strait, off Hondo, Japan, 302 fathoms, Recent.

Recent distribution: — Uraga Strait 302 fathoms (Dall, 1925); off Hondo 369 fathoms (Dall, 1925); off Honshu 300 m (Taki and Otuka, 1943); Sagami Bay 200 m (Taki and Otuka, 1943); Shikoku-Sagami-Kochi 150–800 m (Habe *in* Uchida, 1960).

Turcicula (*Turcicula*) *osawanoensis* (Tsuda, 1959)

Pl. 10, figs. 3, 9, 22

Lischkeia (*Turcicula*) *osawanoensis* Tsuda, 1959, p. 80–81, pl. 3, figs. 12–14.

The present species was first described on the specimens from the Middle Miocene Kurosedani Formation in Toyama Prefecture by Tsuda (1959) under the name of *Lischkeia* (*Turcicula*) *osawanoensis*. He gave the following description: –

"Shell medium in size, rather thin, somewhat highly conical. Nuclear whorls 1.5, small, round and smooth; post-nuclear whorls 6, convex, spirally sculptured with 3 coarse spiral rows of prominent spinous tubercles, the upper row subsutural, weaker than the others; the lower row of the upper whorls nearly suprasutural in position; a very weak, granular, suprasutural spiral thread seen below on the lower whorls; tubercles of each row equal to another in number, about 30 on the body whorl and 25 on the penultimate, the upper interspace of the tubercular rows as wide as the lower; the maximum diameter measured at the lower row; incremental lines fine, slightly oblique; body whorl large, regularly rounded. Suture well-defined on the higher part of the spire by the square furrow lying between the subsutural and suprasutural rows of tubercles; linear but distinct on the lower part. Base roundly convex, with 7 subequal spiral cords; basal cords rather flat, granular, narrower than interpsaces; numerous slightly sinuated incremental lines crossing over the spirals. Aperture oblique, roundly quadrate; outer and basal lips thin, smooth and pearly inside, inner lip thin, broadly to the base covering the umbilicus. Columella short, oblique, with a week tubercle. Measurement: Holotype; Height 17.5 mm, Diameter 15.5 mm, Apical angle 62°, Paratype; Height 22.0, Diameter 22.0, Apical angle 57°."

According to Tsuda (1959), the present species is characterized by having three conspicuous spiral rows of tubercles ($A_1A_2A_3 \rightarrow P$) and roundly convex base with 7 subequal spiral cords. The species was referred to *Turcicula* not *Lischkeia* because the latter has flattened bottom and rather acute corner at the base and the former is characterized by swollen or convex body whorl and base. This species is the only one reported from the Middle Miocene in Japan Sea borderland up to date. *Lischkeia cidaris* (A. Adams, 1864) somewhat resembles the present species in having more conspicuous three tuberculous rows, swollen body whorl and base with 7–8 spiral cords. In 1909, Dall recognized the subgenus *Cidarina* in the genus *Lischkeia* Fischer, 1879 like *Turcicula*. *Cidarina* had been questioned by Pilsbry (1889), Williamson (1892), Taylor (1895), Arnold (1903), Dall (1921), Oldroyd (1927), Grant and Gale (1931), Keen, (1937), Burch (1946), Smith and Gordon (1948), Abbott (1954) and Palmer (1958) as to whether *Cidarina cidaris* belongs to *Lischkeia* or *Turcicula*. From the illustrations and descriptions by the above cited authorities,

Cidarina may be judged to be an independent genus because the surface sculpture, basal characters and closed umbilicus differ from other genera. *Cidaris* slightly resembles the present species but has more distinct tuberculous rows and spiral cord in whorl and stouter shell materials. Though Tsuda (1959) compared *osawanoensis* with *crumpi*, the former differs from the latter in having more tubercles in a spiral row. *Turcicula macdonardi* Dall (1889a) resembles the present species in having small and numerous tubercles in a row but the latter has only one spiral tuberculous row. *Turcicula arnoldi* Durham (1944) resembles the present species in the external sculptures but the former differs from the latter in having whorls biangulated with small tuberculous rows.

Type locality: Tsuzara, Osawano-machi, Kami-Nikawa-gun, Toyama Prefecture, Kashio Alternation of the Kurosedani Formation, Middle Miocene. Holotype preserved in Kyoto University, JC 1400031 (Holotype) and JC 1400032 (Paratype).

Recorded formation: Kashio Alternation of the Kurosedani Formation in Toyama Prefecture.

Geological age: Middle Miocene.

Turcicula (*Turcicula*) *tsudai* Noda, n. sp.

Pl. 9, figs. 16, 20, 21, Pl. 10, fig. 23, Pl. 12, fig. 2

Shell medium in size, with pearly shell, high trochoid form, nucleoconch broken, 4 post-nuclear whorls convex, rather stout with 3 strong nodulous tuberculous rows, about 20 or 19 tubercles in lower row, slightly decreasing in size and number towards upper in a whorl, and suture lines deeply channeled. Body whorl and basal part swollen with 4 elevated spiral cords each narrower than their smooth interspaces, regularly spaced. Aperture roundly quadrate. Inner lip thin, covered with broad umbilicus. Formula $\mathbf{A_1A_2A_3 \rightarrow P}$.

Dimension:	Diameter	Height	Apical angle
Holotype	26.8mm	29.5mm	64°
Paratype	10.5mm	11.1mm	72°

Comparison and *affinities*: The present new species resembles *Turcicula osawanoensis* (Tsuda, 1959) in shell form and arrangement of tubercles but the former differs from the latter in having fewer, strong, rather nodulous tubercles in a whorl. Base of shell with 3 or 4 elevated spiral cords in the new species but with 7 subequal spiral cords in *osawanoensis*. *Turcicula japonica*, a Recent species resembles the new species in the three nodulous rows but the former differs from the latter in having small nodulous and elevated spiral cords on body whorl, and fewer tubercles compared with the latter. So far as known at present, *Turcicula tsudai* is related with *Turcicula japonica*. *Turcicula crumpi* (Pilsbry) differs from the new species in having 3 distinct rows of rather prominent tubercles in a whorl. The present species known only from the type locality.

Type locality: River side cliff of Nishidani-gawa, about 200 m south of Hanzogane, Tochio City, Niigata Prefecture, Shiiya Formation, Late Miocene, Holotype IGPS no. 91753, Paratype IGPS no. 91758.

Subgenus *Bathybembix* Crosse, 1892

Type species: *Bembix aeola* Watson, 1878, Recent.

Bembix Watson, 1878, vol. 14, p. 603.
Bathybembix Crosse, 1892, vol. 40, p. 290–291.
Bathybembix Crosse, Knight *et al.*, *in* Moore, 1906, p. N253.

Bathybembix Crosse, MacNeil, 1960, p. 22.
Bathybembix Crosse, Kuroda, Habe and Oyama, 1971, p. 30, p. 40.

The subgenus *Bathybembix* was proposed by Crosse in 1892 for *Bembix* Watson, 1879 because the name was preoccupied by Konick (1844). The present subgenus is defined by its swollen shell, rather large size with no distinct tuberculous row or rows on surface but with weak tuberculous rows and sigmoidal longitudinal folds, small beaded subsutural row and deep suture lines. *Bathybembix* differs from the subgenus *Ginebis* in having no distinct tuberculous rows on the shell surface. The formula of the present subgenus is shown by $\overline{\mathbf{ba_1a_2a_3}}\rightarrow\mathbf{P}$ or $\mathbf{ba_1a_2a_3}\rightarrow\mathbf{P}$.

Turcicula (*Bathybembix*) *aeola* (Watson, 1878)

Pl. 10, figs. 16, 17

Bembix aeola Watson, Watson, 1878, p. 603. (*fide* Watson, 1886).
Bembix aeola Watson, Watson, 1886, p. 95–96, pl. 7, fig. 13.
Bathybembix aeola Watson, Pilsbry, 1889, p. 162–163, pl. 40, figs. 10–11.
Bathybembix aeola Watson, Crosse, 1892, p. 291.
Bathybembix aeola Watson, Pilsbry, 1895, p. 97.
Bathybembix aeola Watson, Schepman, 1905, p. 100, pl. 8, figs. 4–5. (*fide* Dall, 1909).
Turcicula aeola (Watson), Taki and Otuka, 1943, p. 98–100, pl. 1, fig. 1.
Turcicula (*Bathybembix*) *aeola* (Watson), Kira, 1956, p. 12, pl. 6, fig. 4.
Lischkeia aeola (Watson), Horikoshi, 1957, pl. 11, fig. 20.
Bathybembix (*Bathybembix*) *aeola* (Watson), Knight *et al.*, *in* Moore, 1960, fig. 163–7.
Turcicula (*Bathybembix*) *aeola* (Watson), Kira, 1963, p. 12, pl. 6, fig. 4.
Bathybembix aeola (Watson), Okutani, 1966, p. 15, pl. 1, fig. 15.
Bathybembix aeola (Watson,) Okutani, 1968b, p. 26.
Bathybembix cf. *aeola* (Watson), Shikama and Masujima, 1969, pl. 5, figs. 11–12.
Bathybembix aeola (Watson), Kuroda, Habe and Oyama, 1971, p. 30, pl. 9, fig. 3, p. 44.

Watson's (1878) original description of the present species is given below which was quoted by Watson in 1886.

"*Shell*-High, concavely conical, carinated, sculptured on the upper whorls, smooth or wrinkled below, thin, with a tumid lirated base, narrowly umbilicated, with a smooth epidermis, thin, but especially so on the base. More or less nacreous all over under a thin porcellanous upper layer. *Sculpture*: The first three whorls (after the embryonic apex) are reticulated by three sharp remote spirals, and rather stronger, slightly oblique longitudinals, which rise at their intersection into small sharp pyramidal tubercles; the interstices are a little broader than high. This system gradually dies out and leaves the surface smooth, only the row of infra-sutural tubercles survives in an enlarged but depressed form, and springing from these some sinuous, oblique, and slightly irregular longitudinal puckerings appear on the last whorl, which is nearly bisected by the sharpish, slightly expressed, finely tubercled carina. This bisection of the last whorl arises from the great prolongation and tumiditity of the base, on which, below the carina, are five narrow, equally parted, spiral threads, and two intra-umbilical ones, which are more continuous. Besides this larger system of sculpture, the whole surface is covered with minute, oblique, irregular, and interrupted puckerings of the epidermis. *Colour* a brownish yellow, but below the epidermis there is a thin pure white porcellanous layer, though which and the epidermis the sheen of the nacreous layer gleams. The base is whiter, the epidermis there being very thin. Inside the mouth is an exquisite roseate nacre. *Spire* high, with a slightly concave contour, the lines of which are hardly swollen out by the slight tumidity of the last whorl. *Apex* eroded, but evidently small. *Whorls* 7 or 8, of regular increase, quite flat on the side slopes, except the last, which is very slightly constricted below the suture, a very little tumid on the upper slope, sharply carinated but not much angulated at the suture, and very tumid on the base. *Suture* linear, strongly defined on the upper whorls by the square furrow lying between the lines of tubercles which marginate the suture above and below. On the last whorl it becomes

slightly pouting, from the projection of the carina and the slight infra-sutural constriction. *Mouth* nearly square, very little oblique in the line of its advance, but standing out a little obliquely to the axis of the shell. *Outer lip* thin, not descending. *Pillar-lip* thin, spread out broadly at its base over the umbilicus, which it largely conceals, with a deep narrow furrow behind it. Curving over to the right, it advances, thin and pointed, to its angular junction with the basal lip. *Umbilicus* defined by a spiral thread and with other spirals within it. It is not small but is concealed by the pillar-lip. H. 0.82 in. B. 0.63, least 0.53. Penultimate whorl, 0.19. Mouth 0.4; bradth 0.38."

As described by Watson (1886), *aeola*, known as a deep sea dweller (Fig. 3), with no previous geological record, is characterized by having no distinct tuberculous row in the whorl, with reticulated sculpture on the immature whorls and somewhat sigmoidal folds on the later whorls. The base is sculptured with 8–9 spiral, narrowly elevated threads. The first record of this species as fossil is from a pale gray very fine grained tuffaceous siltstone of the Late Miocene Nobori Formation in Kochi Prefecture. Besides the specimens collected by the writer were found in the collection of the Kochi University, and these were donated to the writer for the study by Prof. Jiro Katto. This occurrence is geologically the oldest known one at present. Recently, Shikama and Masujima (1969) recorded *Bathybembix* cf. *aeola* (Watson) from their Pliocene Imaizumi bed though without description, but their illustrations refer it to the present species based upon the surface sculpture and shell form. Their record of a Pliocene specimen is the first from Honshu, Japan. The geological records just cited of the species are important for interpretation of the migration and evolutional trends of the genus *Turcicula*.

Type locality: Station no. 232, Lat. 35°11'N., Long. 139°28'E, off Enoshima, Japan, 345 fathoms, Recent.

Geological distribution: Nobori Formation in Kochi Prefecture (IGPS no. 91752), Imaizumi Formation in Kanagawa Prefecture.

Recent distribution: Off Enoshima=Challenger st. 232, 345 fathoms, Enshu-nada=Challenger st. 235, 565 fathoms (Watson, 1886); Sagami Bay 600–1020m (Horikoshi, 1957; Okutani, 1968a, b); Enshu-nada 650–1028m (Horikoshi, 1957; Okutani, 1968b); Kashima-nada 300m (Okutani, 1968b); Kashima-nada to Shikoku (Habe *in* Uchida, 1960; Kira, 1963); off Choshi 180–240m (Shikama, 1962).

Geological range: Late Miocene to Recent.

Turcicula (*Bathybembix*) *bairdi* (Dall, 1889)

Pl. 9, fig. 17, Pl. 10, fig. 10, Pl. 12, figs. 1, 12

Margarita (*Turcicula*) *bairdii* Dall, 1889a, p. 377.
Margarita (*Turcicula*) *bairdii* Dall, Dall, 1889b, p. 346–348, pl. 7, fig. 3.
Turcicula bairdii Dall, Oldroyd, 1927, p. 191.
Turcicula bairdii Dall, Keep, 1936, p. 164, fig. 135 (*non vidi*.).
Turcicula bairdi Dall, Taki and Otuka, 1943, p. 100–101, pl. 1, fig. 6, text-fig. 4.
Lischkeia (*Turcicula*) *bairdii* Dall, Shikama and Horikoshi, 1963, p. 11, pl. 8, fig. 4.
Lischkeia (*Turcicula*) *bairdi* Dall, Abbott, 1954, p. 109, pl. 3, fig. c.
Bathybembix aeola (Watson), Okutani, 1964, p. 380–381, pl. 1, figs. 1–2.
Turcicula bairdii Dall, Parker, 1964, pl. 8, fig. 2.

The present species was originally described on specimen from station no. 2839, off San Clemente Islands, California in 414 fathoms by Dall (1889b) as follows*:–

"Shell large, turbinate, elevated, thin, inflated, with four and a half or five whorls, of which the

* Original description of the species was based upon the soft part (1889a) and subsequently Dall added the morphological description above cited (1889b), quoted from Oldroyd (1927).

last is much the largest; surface apt to be eroded, but where perfect covered with an extremely thin, dense, vernicose, pale apple-green epidermis; whorls inflated; suture deep, not channeled; apex moderately pointed; spiral sculpture of (1) numerous fine, faint, rather irregular scratches or impressed lines; (2) sparse slightly elevated revolving bands which are usually more or less nodulous, the nodules when prominent being sharp and laterally flattened as if pinched up; of these there are on the upper whorls usually three series between the sutures, of which one at the periphery is the most prominent and persistent, the next one behind it, halfway between the periphery and the suture, being the least marked; on the base the cinguli are six or seven in number, becoming narrower toward the axis, smaller than those behind the suture, with smaller, less prominent, rounder, and more numerous nodules; there is some variation in number and strength of all the cinguli, but that on the periphery is the most prominent and constant; the whorls are particularly round and inflated above and below, so that the outline of the aperture is often nearly circular; interior of the aperture brilliantly pearly, a thin wash of callus on the body; the outer lip very slightly thickened and distinctly reflected in the adult; pillar thin, simple, arching roundly into the curve of the base without any interruption, angle, or tooth; axis imperforate; the external sculpture showing through the thin shell. Altitude 50; maximum diameter 42 mm. Maximum diameter of operculum 18 mm, with about twelve whorls. The operculum is externally polished, smooth and deeply concave; the inner side presents a minute, central, rounded, elevated point; the margin is very thin but entitre. Hab. Station 2839, off San Clemente, California in 414 fathoms, sand; bottom temperate not registered. *Soft parts* — The side of the foot below the epipodial line are granulous; above the line the surface is rather smooth. Much of the surface is apt to be covered with a layer of blackish or olivaceous substance, like solidified mucus or paint, which seems to belong to the animal, yet is wholly external to the cuticle. The foot is broad, not very long, bluntly pointed behind; the front edge straight, double, the lateral angles pointed. The upper layer of the edge is smooth and turgid in most of the specimens, it is not indented in the median line. The muzzle is stout, circularly wrinkled, a little expanded at the disk. The oral disk is not marginated; its surface is finely granulose; it is angulated at its lower outer corners and medially indented below. There are no oral palps or tactile appendages. The cephalic tentacles, for the size of the animal are small and short. At their inner bases are small "palmettes" or cephalic epipodial fringes, not quite meeting in the middle line. They are rounded, with papillose edges. At the outer bases of the tentacles are the eyes, large, oliviform mounted on short pedicles. The pigmented portion itself is ovoid and not hemispherical. In some specimens the pigment seems to be more extensive on the under side, in others the reverse, and still others have it equally distributed. A lens and aqueous humor are distinctly observable. At the right side, behind and on a level with the eye, is a short tubular verge. The anterior epipodial side-lappet does not appear to be modified into a seminal conduit, as in *Margarita infundibulum* Watson. These lappets are nearly symmetrical. Their base are turned up a little on each side behind the eyes, and the lappets are rather wide. They extend backward about two thirds of the way to the operculum, with a finely palillose edge. Then comes a single tentaclar filament, less than half as long as a cephalic tentacle. There is another strech of edge fringed with only small papillae; under the operculum there are three long filaments, of which the posterior is longest. Behind the operculum the epipodial lines of the two sides approach each other and bound a median furrow, coarsely transversely rdiged (as in *Pleurotomaria*), which extends to the end of the foot. The mantle-edge is smooth or very sparsely papillate, slightly thickened. The free end of the intenstine projects on the right side over the neck, with its termination constricted by a sphincter, and then expanded into a cup-shaped circular foramen. On the left side is the gill, consisting of a central somewhat muscular, ensiform basement, from which depend two sets of elongate-triangular lamellae separated by a narrow ridge. The left-hand set are slightly the longer. Most of the gill is free. Its distal end is pointed, and the lamellae hang, side by side, with the ridge between the two series, as in *Nucula*. The intestine takes a curve to the left side, where the renal gland is visible between it and the gill. I observed no osphradium. The mouth is small. A short distance behind it is a deep radular diverticulum. The jaw are small, triangular, and dark brown. The gullet opens almost directly into an elongate large longitudinally wrinkled stomach. Behind it the very large intestine, with longitudinally striated walls, extends backward about half a whorl, then turns upward and forward for a third of a whorl; then back again upon itself about the same distance; then forward to its anal termination, above described. The liver and seminal gland appear to resemble those of ordinary Trochids. The operculum is ambar-colored, polished, thin, and centrally depressed. It has about

a dozen whorls. The opercular pad is ovoid and rather small. The radula is quite small and the anterior part dark brown. The intestine in all the specimens is crammed with a greenish mud consisting of disintegrated foraminifera. The dentition recalls that of *Calliostoma, Solariella, Margarita,* etc., and presents nothing very characteristic. The central tooth has a broad thin base, subrectangular, and a little wider at the anterior corners. The stem of the cusp and the cusp are narrow. The latter is simple, rather small, short and recurved. It is not denticulate. There are three or four admedian or lateral teeth, rather long, with small bases, rather broad simple moderately curved brownish cusps. There are about twenty-five uncini, half of which spring from lozenge-shaped bases looking like a pavement, are long, narrow, slender, moderately curved, with spatuliform tips. One edge of these tips is microscopically serrate, and below the serrate part on the same side is a single larger denticle, standing out like a short thumb. The external uncini are thin, flat, wide, and hardly curved. Their distal ends are flat and broad, with the edge simple and entire. These teeth gradually diminish in size and width, as in Trochidae. The formula would be 25+3+1/1+3+25, or very nearly that, but time has been wanting in which to undertake the laborious task of an exact enumeration of these minute and tangled objects, of which the general features have just been recorded."

Bairdi is characterized by the convex shell, deeply channeled suture lines, three small tuberculous rows on the whorl with the lower sub-sutural beaded row and 6–7 spiral threads on the convex base. There are 35–40 tubercles in the lower spiral row and slightly fewer ones on the upper and middle at the later stage. The umbilicus is closed and the inner lip smooth. Three small tuberculous rows become indistinct near the subrounded aperture. The whole whorls are sculptured with very fine sigmoidal striations and somewhat wrinckly or sigmodial folds.

The present species resembles *Turcicula aeola* (Watson) in the shell form and sculptures on the younger stage but the former ($\mathbf{bA_1A_2A_3 \rightarrow P}$ or $\mathbf{a_1a_2a_3 \rightarrow P}$) differs from the latter ($\overline{\mathbf{a_1a_2a_3 \rightarrow P}}$) in having deeply channeled suture lines, subsutural beaded row and three small distinct tuberculous rows. *Bathybembix aeola* of Okutani (1964) from Sagami Bay is characterized by three small tuberculous rows and convex shell form and may be referred to *bairdi* of Dall (1889a, b). It is noteworthy that *Turcicula aeola* and *Turcicula bairdi* resembles each others; the former has three blunt spiral cords on the younger whorls which become sigmoidal folds on the penultimate and body whorls, and these somewhat resembles the three tuberculous rows on *Turcicula bairdi* which has sigmoidal like folds near the aperture. However, the tubercles on the younger whorls of *Turcicula bairdi* are conspicuous compared with those of *Turcicula aeola.* Present species is not known as fossil.

Type locality: Off San Clemente Islands, California in 414 fathoms, Recent.

Recent distribution: Off San Clemente Islands, 414 fathoms (Dall, 1889a); Bering Sea to N.W. of Unimak Islands, 27 fathoms (Dall, 1921); Bering Strait 50m (Taki and Otuka, 1943); Alaska-Canada-California 180–1100 m (Habe, 1961); Bering Sea to Coronado Island, Mexico 100–600 fathoms (Abbott, 1954); off Point, Pinos 418–581 fathoms (Smith and Gordon, 1948); Coast of Washington to Coronado Islands 238–822 fathoms (Dall, 1921); Sagami Bay 550–770 m (Okutani, 1964).

Subgenus *Ginebis* Taki and Otuka, 1943

Type species: *Turcicula* (*Ginebis*) *argenteonitens argenteonitens* (Lischke), Recent.

Ginebis Taki and Otuka, 1943, p. 96.

Ginebis Taki and Otuka, Knight *et al.*, *in* Moore, 1960, p. N253.

Ginebis was proposed by Taki and Otuka (1943) and used by many malacologists (Habe, 1961; Kira, 1959, 1963; Okada and Taki, 1960; Shikama and Masujima, 1969; Kuroda, Habe and Oyama, 1971; Shikama, 1973). However, the name seems to be not defined according to the "International Code of Zoological Nomenclature" (Stoll *et al.*,

1964, Article 13 (a), (b)). Another problems is; Taki and Otuka (1943) separated the turciculid gastropods into two groups, namely, *Turcicula argenteonitens, T. argenteonitens hirasei, T. convexiuscula*; and *Turcicula aeola, T. bairdi, T. crumpi, T. crumpi yokoyamai, T. japonica* based upon the sculpture of the immature whorles and protoconch. Those authors proposed the new name *Ginebis* for the former group based upon *Turcicula argenteonitens* s.s. At that time they considered *Turcicula imperialis* to be the type species of *Turcicula* of Dall (1881). They presented a species list with a key to the classification of the genus "*Ginebis*" which included the eight species above cited, but omitted *Turcicula imperialis*. *Turcicula japonica* was placed the first group in spite of being classified in the second group. Taki and Otuka described and illustrated all eight species in detail and placed them in the genus *Turcicula*. But in the list of the key to species, all of the species were included into genus "*Ginebis*". They called *Turcicula* as "Igaginebis" and *Ginebis* as "Ginebis" in Japanese in their description, they confused but the usage of the genus name and subgenus name. In their work they included *Bathybembix* Crosse, 1892, and *Bembix* Watson, 1879 into the synonym of their *Turcicula* Dall, 1881, the type species of which was included in their "subgenus" *Ginebis* in the same paper. Regardless of the taxonomic confusion, Knight *et al.* (*in* Moore, 1960) and some malacologists treated *Ginebis* as a valid taxonomic unit. However, Rehder (1955) and MacNeil (1960) considered the monograph of the Japanese *Turcicula* of Taki and Otuka (1943) to represent a monograph of the Japanese *Bathybembix*. From the above reasons, and to clear up the existing confusion, the definition and characteristics of *Ginebis* are as follow.

Ginebis was originally recognized by the smooth surface of the protoconch and the two spiral tubercules with longitudinal sculpture on the immature whorl by Taki and Otuka (1943). Such characters are important in the classification of the turciculid gastropoda, and to it should be added, the rather strong tuberculous row situated intermedially on the surface and subsutural small beaded rows. Some species of the present subgenus have only tuberculous row in the adult stage and smooth surface on immature stage. The body base is rather swollen with 6–8 slightly elevated spiral cords of very small granular beads.

Ginebis resembles *Convexia* in shell form but the former has distinct tuberculous row intermedially on the whorl whereas the latter has no tuberculous row intermedial. *Turcicula* s.s. differs from *Ginebis* in having two or three distinct tuberculous rows and rather small size.

Turcicula (*Ginebis*) *argenteonitens argenteonitens* (Lischke, 1872)

Pl. 9, figs. 1–3, 11–12, 14, 18, Pl. 10, fig. 4, Pl. 11, figs. 2, 4, 6, Pl. 12, fig. 6

Trochus argenteonitens Lischke, 1872, Malak. Blatt, 19, p. 104, (*fide* Lischke, 1874)
Trochus argenteonitens Lischke, Lischke, 1874, p. 66–67, pl. 4, fig. 1.
Bathybembix argentoenitens (Lischke), Crosse, 1892, p. 291–292, pl. 4, figs. 4, 4a, 4b.
Calliostoma argenteonitens Lischke, Pilsbry, 1889, p. 346–347, pl. 63, fig. 32.
Bathybembix argenteonitens Lischke, Pilsbry, 1895, p. 97.
Turcicula argenteonitens (Lischke), Taki and Otuka, 1943, p. 105–106, pl. 1, fig. 3.
Lischkeia (*Ginebis*) *argenteonitens* (Lischke), Tsuchi, 1955, fig. 7.
Turcicula (*Ginebis*) *argenteonitens* (Lischke), Kira, 1956, p, 142–143, pl. 6, fig. 6.
Lischkeia argenteonitens argenteonitens (Lischke), Horikoshi, 1957, pl. 11, figs. 18–19.
Bathybembix (*Ginebis*) *argenteonitens* (Lischke), Taki *in* Okada, 1960, p. 183, pl. 84, fig. 21.
Bathybembix (*Ginebis*) *argenteonitens* (Lischke), Kuroda and Habe *in* Okada, 1965, p. 27, fig. 66.
Turcicula argenteonitens (Lischke), Shuto, 1961, p. 193–194, fig. A on p. 194.
Lischkeia (*Turcicula*) *argenteonitens argenteonitens* (Lischke), Shikama and Horikoshi, 1963, p. 10,

pl. 8, fig. 5.
Turcicula (Ginebis) argenteonitens (Lischke), Kira, 1963, p. 12, pl. 6, fig. 4.
Ginebis argenteonitens (Lischke), Shikama and Masujima, 1969, pl. 5, figs. 14–15.
Turcicula crumpi yokoyamai Otuka, Shikama and Masujima, 1969, pl. 5, figs. 10, 13.
Ginebis argenteonitens (Lischke), Kuroda, Habe and Oyama, 1971, p. 30, pl. 9, figs. 7, 8, p. 45.
Ginebis argenteonitens (Lischke), Shikama, 1973, p. 196, pl. 16, figs. 5, 6.

The present species was described by Lischke (1874) as,

"Testa imperforata, conoidea, apice acuto, tenuis, flavescens, splendore margaritaceo pellucido subargentea; anfractus 8 convexiusculi, striis incrementi obsoletis sculpti, ad suturam utrinque concinne crenulati; anfractus tres ultimi tuberculorum serie mediana ornanti; anfractus ultimus dimidiam fere totius altitudinis partem aequans, ad basem carina acuta, compressa cinctus; basis valde convexa, costis spiralibus 8 angustis, crenulatis, primis tribus remotis, reliquis approximatis instructa; apertura subquadrate-rotunda; columella sinuata, vivide margaritacea. alt 43, lat 30 mill. Habitat prope Jedo."

The present species is characterized by the surface sculptures of **bAb→P**; the whorls of the immature stage with faint longitudinal and spiral lines making a reticulated sculpture, no distinct tuberculous row but small beaded rows subsuturally. The last two or three whorls are characterized by 15–17 rather distinct, knob-like tuberculous row intermedially in a whorl and, above and below the subsuturally beaded rows. There are 6–7 spiral ridges with small beads narrower than the interspaces on the convex swollen base. The inner lip is narrow and the umbilicus closed. *Turcicula argenteonitens hirasei* is distinguished from the present species by the distinct tuberculous row intermedially in whorl of the every whorls shown by **bAb→P**. The present species was recorded from the Pliocene and Pleistocene deposits around the Kanto region such as the Nojima, Koshiba formations in Kanagawa Prefecture, Kechienji and Hatagaya formations in Shizuoka Prefecture, Sanuki, Otadai and Kakinokidai formations in Chiba Prefecture.

Type locality: Jedo (Tokyo), precise locality not given.

Geological distribution: Takanabe Formation in Miyazaki Prefecture (Shuto, 1961); Hijikata and Kechienji formations in Shizuoka Prefecture (Tsuchi, 1955; IGPS no. 78654); Nojima Formation (Shikama and Masujima, 1969; IGPS nos. 17850, 17852) and Koshiba Formation (IGPS nos. 24295, 43704) both in Kanagawa Prefecture; Tomioka Formation (IGPS no. 43606), Sasage Formation (IGPS no. 46293), Kiwada Formation (IGPS no. 85615) and Na-arai Formation (IGPS no. 16212) all in Chiba Prefecture; Mamurogawa Formation in Yamagata Prefecture (IGPS no. 91754); Zushi Formation in Kanagawa Prefecture (Shikama, 1973).

Recent distribution: South of Suruga Bay 30–50 fathoms (Kira, 1963); off Boso to Taiwan (Formosa) 50–100m (Taki *in* Okada, 1960; Habe and Kosuge, 1967); South of Boso Peninsula (Taki and Otuka, 1943); Southwest of Miura Peninsula (Kira, 1963); Suruga-wan 100–200m (Tsuchi, 1955, 1956, 1958); off Tosa (Horikoshi, 1957; Shikama and Horikoshi, 1963).

Geological range: Late Miocene to Recent.

Turcicula (Ginebis) argenteonitens hirasei Taki and Otuka, 1943

Pl. 9, fig. 24, Pl. 10, figs. 14, 24, Pl. 11, figs. 3, 5, Pl. 12, figs. 8, 13

"*Turcicula argenteonitens*" Lischke, Yamakama, 1934, pl. 49, fig. 1.
Turcicula argenteonitens hirasei Kuroda, MS., Taki and Otuka, 1943, p. 106–107, pl. 1, fig. 4.
Turcicula argenteonitens (Lischke), Hirase, 1934, pl. 69, fig. 6.
Lischkeia aregenteonitens hirasei (Taki and Otuka), Taki *in* Hirase, 1954, pl. 69, fig. 6.

Turcicula (*Ginebis*) *argenteonitens* (Taki and Otuka), Kira, 1956, pl. 6, fig. 5.
Turcicula argenteonitens hirasei Kuroda, Shuto, 1961, p. 193–195, fig. C on p. 194.
Turcicula (*Ginebis*) *argenteonitens hirasei* (Taki and Otuka), Kira, 1963, p. 12, pl. 6, fig. 5.

The subspecific manuscript name *hirasei* of Kuroda was used by Taki and Otuka, 1943 in a formal way whereby they became the authors of the shell. This subspecies is characterized by the distinct tuberculous row intermedially in a whorl and above and below with subsutural beaded rows shown by **bAb→P**. The immature whorls are provided with reticulated sculpture. There are 17–20 tubercles in a row on the later stage and somewhat knob-like. The lower subsutural beaded row is distinct and much in number compared with the upper one which transform into a spiral cord on the base. There are some variations in the surface sculpture; the specimen from off Matsushima, Miyagi Prefecture has paired subsutural beaded rows on the upper part of the body whorl indicated by **bAb$_1$b$_2$**. Base rather swollen and convex with 7–8 spiral cords and fine interstitial spiral striations (secondary spiral striations). Aperture somewhat rounded. Inner lip smooth and pearly bright. Umbonal part closed.

Comparison and *affinities*: *Turcicula argenteonitens hirasei* differs from *T. arg. argenteonitens* in having distinct prominent tuberculous row intermedially in whorl. The latter has smooth surface on the younger whorls. Kira (1956, 1959, 1963), Taki (1954), Okutani (1968a), Horikoshi (1957), and Shuto (1961) stated that the *argenteonitens argenteonitens* represents the southern type and *argenteonitens hirasei* the northern. The distribution of the two types diverge off the Boso Peninsula, Chiba Prefecture. *T. arg. hirasei* resembles *T. hataii*, n. sp. in the external sculptures but the latter differs from the former in having distinct lower subsutural row of beads with small dotted basal spiral cords.

The present subspecies is not known as fossil.

Type locality: Not decided by the authors.

Recent distribution: Off Kuji (IGPS no. 17244); off Choshi 120–270m (Shikama, 1962); North of Sagami Bay 30–50 fathoms (Kira, 1963); North of Honshu (Kira, 1956; Taki and Otuka, 1943); off Sanriku (IGPS nos. 91757, 10121; Taki *in* Hirase, 1954); off Kashima (Horikoshi, 1957).

Turcicula (*Ginebis*) *hataii* Noda, n.sp.

Pl. 9, figs. 6, 9, 15, Pl. 12, figs. 7, 10, 11

Shell thin, small, trochoid, 6 whorls and protoconch. Body whorl somewhat convex, younger whorls rather slender. Aperture somewhat roundly-quadrate in form. Surface sculptured with upper and lower subsutural rows of small beads and distinct intermedial tuberculous row shown by **bAb→P**. Lower subsutural beaded row distinct from second to thrid whorl and upper one with smaller tubercles compared with the former. Lower subsutural beaded row extends to upper spiral threads on base with distinct shortly elevated folds. Intermedial tuberculous row with 14–15 tubercles, rather conspicuous. Suture lines rather channeled. Protoconch smooth, with longitudinal striations. Base swollen, sculptured with 5 distinct elevated spiral cords with shortly elevated folds and smooth interspaces of cords. Umbilicus closed and inner lip narrow.

Dimension	Height	Width	Height of Aperture	Width of Aperture
Holotype	15.1 mm	12.1 mm	7.9 mm	6.9 mm

Comparison and *affinities*: The present species is characterized by **bAb→P**. Surface of younger stage reticulated in sculpture. The present new species resembles the younger form

of *Turcicula argenteonitens hirasei* Taki and Otuka in the surface sculpture (**bAb→P**) but the former has distinct and characteristic beaded rows at the lower and upper parts of a whorl, whereas those of the latter are smaller and weaker. *Turcicula crumpi* differs from the present new species in having three conspicuous tuberculous rows.

The present new species is known only from the type locality as Recent form.

Type locality: Off Kinka-san, Miyagi Prefecture, 52 fathoms, Recent, Holotype IGPS no. 17149.

Turcicula (*Ginebis*) *nagaoi* Noda, n. sp.

Pl. 9, fig. 19, Pl. 10, fig. 6

Turcicula sp. indet., Nagao, 1928, p. 117, pl. 18, fig. 10.
Lischkeia sp., Oyama, Mizuno and Sakamoto, 1960, p. 28, pl. 1, fig. 8 (reproduced from Nagao, 1928).

The present species was originally described by Nagao (1928) from the Manda Group (correlated with the Kattachi Formation) under the name of *Turcicula* sp. indet. with the following description:—

"Shell turbinate, with a high spire. Whorls 6 or 7 in number, each angulated at a little above the mid-point of its depth, sloping above and nearly vertical below the angle; ornamented with two spiral rows of low, round tubercles; the upper one lying on the angle and more prominent than the lower, and the lower one situated along the margin. Body whorl large, biangulated, each angle bearing a row of tubercles; the interspace between the two angles flattened and vertical; the lower angle rounded; base convex, ornamented with about five, closely nodulous, spiral ribs narrower than the interspaces; columella regularly arcuated. Tubercles prominent, spirally elongated and rather distant. About 37 mm in height."

To the original description may be added that, there are two tuberculous rows, parallel with each other on the body and penultimate whorls. The lower row with 24–25 small tubercles becomes distinct on the penultimate whorl, and continues to the uppermost basal cords subsuturally. So that the present species seems to have two tuberculous rows in a whorl but its formula is **bA→P**. The upper one 17–18 in number is located at the middle part on the whorl but it does not appear on the early stage. This tuberculous row is the main intermedial row. Body whorl swollen and umbilicus closed. The upper immature whorl smooth.

Remarks: The present species resembles *Turcicula argenteonitens argenteonitens* and its subspecies in the shell form and mode of tuberculous row but the present species is characterized by formula of **bA→P** and has no upper-sutural beaded row. Whereas *Turcicula argenteonitens argenteonitens* and *hirasei* are characterized by having a distinct tuberculous row intermedially and upper and lower subsutural beaded rows, shown by formula **bAb→P** or **bAb→P**. *Turcicula crumpi* resembles the present species in having distinct tuberculous rows but the former differs from the present species by three tuberculous rows shown by formula $\mathbf{A_1A_2A_3}\rightarrow\mathbf{P}$. *Turcicula sakhalinensis* Takeda (1953) is another allied species but it differs from the present species which has many tubercles and small size compared with the former. The present species is known only from the type locality.

Type locality: The northern foot of the Hakama-dake, Manda, Arao City, Kumamoto Prefecture, Kattachi Formation, Eocene, Holotype IGPS no. 35773.

Turcicula (*Ginebis*) *sakhalinensis* Takeda, 1953

Pl. 10, fig. 15

Turcicula sakhalinensis Takeda, 1953, p. 49–50, pl. 2, figs. 2, 4, 5, 8, 9.
Bathybembix (*Ginebis*) *sakhalinensis* (Takeda), Oyama, Mizuno and Sakamoto, 1961, p. 29, pl. 1, figs. 7a-e (reproduced from Takeda, 1953).

The present species was proposed and described on specimens collected from the Eocene Poronai Formation in eastern Hokkaido and South Sakhalin by Takeda (1953). The original description is:—

"Shell medium, conical, abruptly tapering to apex, (apical angle 62°); whorls 7, but protoconch broken, tubercles appear from second whorl, becoming 2 rows on third whorl but upper one soon disappears, number of tubercles counted 15; on fine crenulation near suture, but on later whorls crenulations appear on upper suture and become distinct and strong on base; 4 sharp rows of crenulations on body whorl; mouth rounded; umbilicus closed."

Dimension	Height	Maximum diameter	Height of mouth
	45 mm	38.5 mm	20 mm
	49 mm	44.5 mm	26 mm

The present species shown by **bAb→P** resembles *Turcicula argenteonitens* s.s. (formula **bAb→P**) in shell size, form and arrangement of the tuberculous row but the former differs from the latter in having fewer intermedial tubercles, discontinuous row of subsutural beads and no secondary spiral striations on the base. *Turcicula nagaoi* differs from the present species in having rather smooth whorls at the younger stage and fewer tubercles in a row.

The present species is known only from the Poronai Formation in eastern Hokkaido and its correlative Maoka Series in southern Sakhalin.

Type locality: Along the main stream 4080 m east of the junction of the first tributary of the Okô River, Honto-gun, South Sakhalin, Maoka Series, Eocene. Holotype UH 11101, Paratype UH 11102–06 (Locality and formation is same to type locality), UH 11197 (Locality and formation is of, River cliff of 170m east from the bridge of Omagari, middle course of Charo River, Kushiro, eastern Hokkaido, Poronai Formation, Eocene).

Turcicula (*Ginebis*) *sukegawaense* Noda, n. sp.

Pl. 9, figs. 22, 23, Pl. 10, fig. 13

Bathybembix argenteonitens Lischke, Yokoyama, 1925, p. 14, pl. 1, fig. 3.

The species was first illustrsted by Yokoyama (1925) from the Sukegawa Formation in Ibaraki Prefecture under the name of *Bathybemix argenteonitens* with the following description.

"A beautiful shell with the whorl furnished with a single angle, except the last which shows two such angles, the lower one being formed by the periphery. Some specimens are up to 40 millim. in diameter."

After re-examination of the specimens from the type locality at Sukegawa the following characteristics should be described and a new name proposed; Shell rather large, high and swollen. Base convex, umbilicus closed. Suture lines rather deeply channeled. Protoconch unknown. Younger whorls sculptured with spiral row of weak and small tubercles at intermediate of whorl, developing into angular ridge on penultimate whorl,

continuing to apertural end. Lower subsutural beaded row appears at periphery and forms a somewhat ridge-like structure in upper part of swollen base.

Comparison and *affinities*; The new species differs from *Turcicula convexiuscula* (Yokoyama, 1920) which was originally described from the Kanazawa beds, in Kanagawa Prefecture in having keel-like spiral ridges on the penultimate and body whorls and the latter has no intermedial tuberculous row. *Turcicula argenteonitens* s.s. differs from the present species in having distinct tuberculous row and subsutural beaded rows in upper and lower parts on whorl. The present species resmbles *Turcicula macdonardi* Dall (1889b) described from the Recent sea of Ecuador in 401 fathoms depth in having small tuberculous intermedial spiral row but the former differs from the latter in having deeply channeled suture lines and elevated spiral row with small tubercles on the penultimate and body whorls.

The present species was collected from several localities along the sea coast of Hitachi where the Pliocene Sukegawa Formation is developed. At the present, the species is known only from the Sukegawa Formation.

Type locality: Sea cliff at Sukegawa, Hitachi City, Ibaraki Prefecture, Sukegawa Formation, Pliocene. Holotype IGPS no. 26634.

Subgenus *Convexia* Noda, n. subgen.

Type species: *Turcicula* (*Convexia*) *convexiuscula* (Yokoyama).

Shell thin, high trochoid, medium in size with pearly luster. Surface with very small beaded rows at upper and lower subsutural without intermedial distinct tuberculous row. Immature whorls with blunt reticulate sculpture. Base convex, rather swollen, with 6–7 spiral, narrowly elevated cords. Inner lip narrow, umbilicus closed. Aperture somewhat roundly-quadrate.

Convexia resembles *Bathybembix* in having similar size, shell form, beaded subsutural rows and basal spiral cords, but the former differs from the latter in having smooth shell surface and not so deep suture-lines whereas the latter has weak but distinct tubercles intermedially and sigmoidal folds. *Ginebis* differs from the present subgenus in having distinct tuberculous row intermedially.

Turcicula (*Convexia*) *convexiuscula* (Yokoyama, 1920)

Pl. 9, figs. 4, 5, Pl. 10, fig. 18, Pl. 11, fig. 1, Pl. 12, fig. 9

Bembix convexiusculum Yokoyama, 1920, p. 90, pl. 5, figs. 32a-b.
Turcicula convexiuscula (Yokoyama), Taki and Otuka, 1943, p. 107–108, pl. 1, fig. 5.
Turcicula convexiuscula (Yokoyama), Taki and Oyama, 1954, pl. 6, figs. 32a-b.
Bembix convexiusculum Yokoyama, Kira, 1956, text-fig. on p. 142.
Turcicula argenteonitens convexiuscula (Yokoyama), Shuto, 1961, p. 193–194, figs. B, D.
Lischkeia convexiuscula tosana Shikama, Shikama, 1962, p. 40, pl. 1, figs. 12–13b.
Bembix convexiusculum Yokoyama, Kira, 1963, text-fig. on p. 12.

The present species was originally described on the specimens from the Pliocene Kamakura beds in Kanagawa Prefecture by Yokoyama (1920) as follows:–

"Shell thin, turbinate, imperforate. Whorls about eight, rather convex, with a spiral row of granules close to the lower as well as to the upper suture and with the intermediate space smooth. Periphery which is formed by the lower row of granules angulated. Base convex with about five distant subnodose spiral threads. Aperture subquadrate or subrhombic with the diagonal from front to behind longer than the other. The best, though not the largest, specimen measures 28 millim. in height and 19 millim. in diameter."

The present species is characterized by the convex trochoid form and rather smooth surface with small beaded subsutural rows at the upper and lower parts on the whorl. The upper small beaded row becomes distinct from the third whorl. The lower one is rather weaker and with more beads than the former and appears from the fourth whorl and continues to the body whorl. The species is shown by **b · b→P.** There are longitudinal ridges like reticulated sculpture at the whorl of the immature stage. Some bluntly spiral ridges are on the middle part of the body whorl and very faint longitudinal striations on the whorls. The description of *convexiuscula* (Yokoyama, 1920) is judged to include *Lischkeia convexiuscula tosana* which was originally described from the Recent sea of off Tosa by Shikama (1962) who gave the following description:–

> "Shell large, broadly conical, high, thin, white with pearly lustre; nine post-nuclear whorls slightly round; base convex like in *argenteonitens* Lischke with 6–7 subnodosed spiral threads, while 5 in *convexiusculum*. Periphery acute with many subgranules; first three whorls distinctly nodosed, while the other whorls very smooth without node. In *convexiusculum* there is seen many obsolete nodules in subsutural band. Aperture subrhombic. Measurement of holotype, Height 53, diameter 43mm".

As stated already, there are some differences between *Turcicula convexiuscula* and *Turcicula convexiuscula tosana* such as number of whorls and spiral threads on the base but these characteristics are of mere variation and not of specific significance. *Turcicula sukegawaense* from the Pliocene Sukegawa Formation in Ibaraki Prefecture which was illustrated by Yokoyama (1925) under the name of *Bathybembix argenteonitens* Lischke resembles the present species in the shell surface and shell form but the former differs from the latter in having distinct or somewhat blunt cordinal ridge on the penultimate and body whorls with small tubercles and beaded subsutural rows. *Turcicula convexiuscula* from the Pliocene Sukegawa Formation associated with *sukegawaense* is characterized by the lower subsutural small beaded row without intermedial tuberculous row, upper subsutural row of beads and 5 or 6 narrowly elevated spiral cords on the base. If the specific criteria is based on the development of the upper subsutural row of beads only, the two forms may be separated into subspecies as stated by Shikama (1962), but in the latter case, the subspecies of Shikama (1962) from off Tosa should be given a different name because Shikama (1962) included the original species (Yokoyama, 1920) in his synonymic list. As fossil, the species is known only from the Sukegawa Formation in Ibaraki Prefecture.

Type locality: Kewai-zaka, Kamakura City, Kanagawa Prefecture, Urago Formation (=Kamakura bed of Yokoyama), Pliocene, Lectotype CM 20276.

Geological distribution: Urago Formation in Kanagawa Prefecture (=Kamakura Beds of Yokoyama, 1920); Sukegawa Formation, Ibaraki Prefecture (IGPS nos. 17257, 49176).

Recent distribution: Off Tosa 150–200 fathoms (Shikama, 1962; Kira, 1963), off Tosa (IGPS no. 91755).

Geological range: Pliocene to Recent.

Turcicula sp.

Pl. 10, figs. 11, 12

Lischkeia crumpii (Pilsbry), Hatai and Masuda, 1962, pl. 40, figs. 18a–b.

The present species was originally recorded from the Miocene Tokigawa Formation in Saitama Prefecture by Hatai and Masuda (1962). The specimen is characterized by

faint longitudinal folds on the younger shell surface and three small tuberculous rows on the adult whorl and the uppermost tuberculous row is weaker than the other rows. Hatai and Masuda (1962) identified the specimen as *Lischkeia crumpii* but the *crumpi* is characterized by having conspicuous or three distinct tuberculous rows on the surface and a fewer number of tubercles compared with the Tokigawa specimen. From the external characteristics, the specimen from the Tokigawa Formation resembles *Turcicula bairdi*, a Recent species in having longitudinal folds and small tuberculous rows on the adult stage. Unfortunately, the present writer left it unnamed, but it may be a new form of *Turcicula* because such external characters are not known among the turciculid species. The illustrated specimen (Pl. 10, figs. 11, 12) from the Pliocene of South Sakhalin may be refer to the Tokigawa specimen in the external sculptures and left unnamed.

Geological distribution: Tokigawa Formation in Saitama Prefecture (Hatai and Masuda, 1962); Pliocene deposits in southern Sakhalin (IGPS no. 26311).

Geological age: Late Miocene to Pliocene.

References

Abbott, R.T., 1954, American seashells. *D. van Nostrand Comp. Inc.*, Canada, 541pp., 97 figs., 40 pls.

Adams, A., 1864, *See* Carpenter P.P., 1846b. (*fide* Palmer, K.W. van, 1958, p. 137).

Addicott, W.O., Kanno, S., Sakamoto, K., and Miller, D., 1971, Clark's Tertiary molluscan types from the Yakataga district, Gulf of Alaska. *U.S. Geol. Surv., Prof. Pap.*, **750**-*C*, p. 18–33, figs. 1–6, tabs. 1–2.

Akiyama, M., 1957, The Neogene strata along the upper course of the Fujikawa River, Yamanashi Prefecture, Japan. *Geol. Soc. Japan, Jour.*, vol. 63, no. 747, p. 669–683, figs. 1–6, 1 tab. (*in* Japanese with English abstract).

Arnold, R., 1903, The paleontology and stratigraphy of the marine Pliocene and Pleistocene of San Pedro, California. *Calif. Acad. Sci., Mem., 2nd Ser.*, vol. 3, p. 1–420, pls. 1–37.

————., 1908, Descriptions of new Cretaceous and Tertiary fossils from the Santa Cruz Mountains, California. *U.S. Nat. Mus., Proc.*, vol. 34, no. 1617, p. 345–389, pls. 31–37.

Asano, K., 1962, Japanese Paleogene from the view point of Foraminifera with descriptions of new species. *Tohoku Univ., Cont. Inst. Geol. Paleont.*, no. 57, p. 1–32, figs. 1–2, tabs. 1–2, pl. 1.

————., and Hatai, K., 1967, Micro- and macropaleontological Tertiary correlations within Japanese Islands and with planktonic foraminiferal sequences of foreign countries. Tertiary Correlation and Climatic Changes in Pacific, p. 77–87, 2 tabs., *Sasaki Print. Publ. Co. Ltd.*, Sendai.

Burch, B.L., 1946, Comparison of the molluscs of three Pleistocene beds with the Recent fauna of Los Angeles County, California. *Min. Conch. Club., California*, no. 73, p. 1–18.

Carpenter, P.P., 1864a, Diagnoses of new forms of Mollusca from the Vancouver district. *Ann. Mag. Nat. Hist., 3rd Ser.*, vol. 14, nos. 5–37, p. 423–429.

————., 1864b, A supplementary report on the present state of our knowledge with regard to the Mollusca of the west coast of North America. *Rep. British Assoc. Advan. Sci.*, for 1863, p. 517–686.

Clarks, B.L., 1932, Fauna of the Poul and Yakataga formations (Upper Oligocene) of South Alaska. *Geol. Soc. Amer., Bull.*, vol. 43, p. 797–846, pls. 14–21.

Cossmann, M., 1918, Essais de paleontologie comparée. vol. 11, p. 1–388, text-figs. 1–128, pls. 1–11.

Crosse, H., 1892, Études malacologiques sur des genres nouveraux ou peu connus. *Jour. Conch.*, vol. 40, p. 279–292, pl. 4.

Dall, W.H., 1881, Report on the results of dredging, under the supervision of Alexander Agassiz, in the Gulf of Mexico, and in the Carribean Sea, 1877–79 by the United States coast survey steamer "Blake." Preliminary report on the Mollusca. *Mus. Comp. Zool., Bull.*, vol. 9, no. 2 p. 3–144.

————., 1889a, Reports on the result of dredging, under the supervision of Alexander Agassiz, in the Gulf of Mexico (1877–78) and in the Carribean Sea (1879–80), by the U.S. coast survey steamer "Blake", Report on the Mollusca, Part II, Gastropoda and Scaphopoda. *Mus. Comp. Zool., Bull.*, vol. 18, p. 1–492, pls. 10–39.

————., 1889b, Scientific results of explorations by the U.S. fish comission steamer Albatoross. No. 7, Preliminary report on the collection of Mollusca and Brachiopoda obtained in 1887–'88. *U.S. Nat. Mus., Proc.*, vol. 12, no. 773, p. 219–362, pls. 5–14. (*non vidi.*)

————., 1909, Contributions to the Tertiary paleontology of the Pacific Coast. 1. The Miocene of Astoria and Coos Bay, Oregon. *U.S. Geol. Surv., Prof. Pap.*, 59, p. 1–278, pls. 1–23.

————., 1919, Descriptions of new species of Mollusca from the North Pacific Ocean in the collection of the United States National Museum. *U.S. Nat. Mus., Proc.*, vol. 56, no. 2295, p. 293–371.

————., 1921, Summary of the marine shell bearing mollusks of the northwest coast of America, from San Diego, California to the Polar sea, mostly contained in the collection of the United States National Museum, with illustrations of hitherto unfigured species. *U.S. Nat. Mus., Bull.*, 112, p. 1–217, pls. 1–22.

————., 1925, Illustrations of unfigured types of shells in the collection of the United States National Museum. *U.S. Nat. Mus., Proc.*, vol. 66, art. 17, p.1–41, pls. 1–36.

Dautzenberg, Ph., and Fischer, H., 1892, Dragages effectues par L'Hirondelle et par la Princesse-Alice. *Soc. Zool. de France, Mem.*, vol. 10, p. 139–234, pls. 3–7.

Durham, J.W., 1944, Megafaunal zones of the Oligocene of northwestern Washington. *Univ. Calif. Press., Bull. Dep. Geol. Sci.*, vol. 27, no. 5, p. 101–212, figs. 1–7, 1 map, pls. 13–18.

Grant, U.S., and Gale, R.H., 1931, Catalogue of the marine Pliocene and Pleistocene Mollusca of California and adjacent regions. *San Diego Soc. Nat. Hist., Mem.*, vol. 1, p. 1–1036, figs. 1–15, tabs. 1–3, diagrams A-C, pls. 1–32.

Habe, T., 1961, Coloured illustrations of the shells of Japan. (II), 183pp., 66pls., *Hoikusha*, Osaka. (*in* Japanese).

————., and Kosuge, S., 1970, [Coloured illustrations of shells]. 306pp., 64pls., *Hoikusha*, Osaka. (*in* Japanese, original title translated).

Hatai, K., 1962, Mizuho Tô. *Tohoku Univ., Sci. Rep., Sec. Ser., Geol., Spec. Vol.*, no. 5, p. 329–348.

————., 1967, The Oidean. *Essays Celeb. Dr. Hayasaka's* **70***th Birth.*, p. 77–83, *Hashimoto Kakubun-do*, Kanazawa.

————., and Masuda, K., 1962, Megafossils from near Higashi-Matsuysma City, Saitama Prefecture, Japan. *Paleont. Soc. Japan, Trans. Proc., N.S.*, no. 46, p. 254–262, pl. 40.

Hayasaka, I., 1940, Brachiopods from the Kubiki Series of Niigata Prefecture, Japan. *Japan. Jour. Geol. Geogr.*, vol. 17, nos. 1–2, p. 63–67.

Hirase, S., 1934, A collection of Japanese shells with illustrations in natural colours. 217pp. 129 pls., *Matsumura Sanshodo*, Tokyo. (*in* Japanese).

————., 1954, A illustrated handbook of shells in natural colors from the Japanese Islands and adjacent teritory. 124 pp., 134 pls., *Maruzen Book. Co.*, Tokyo. (*in* Japanese).

Horikoshi, M., 1957, Note on the molluscan fauna of Sagami Bay and its adjacent waters. *Yokohama Nat. Univ., Sci. Rep., Ser.* **2**, no. 2, p. 37–64, figs. 1–13, charts 1–2, pl. 11.

Kanno, S., 1971, Tertiary molluscan fauna from the Yakataga district and adjacent area of southern Alaska. *Paleont. Soc. Japan, Spec. Pap.*, no. 16, p. 1–154, figs. 1–20, pls. 1–18.

Keen, M., 1937, An abridged check list and bibliography of west America marine Mollusca. *Stanford Univ. Press.*, 87pp., California.

Kira, T., 1956, Coloured illustrations of the shells of Japan. 204 pp., 67 pls., *Hoikusha*, Tokyo. (*in* Japanese).

————., 1959, *Ibid.*, 230 pp., 71 pls., *Hoikusha*, Tokyo. (*in* Japanese).

————., 1963, *Ibid.*, 239 pp., 71 pls., *Hoikusha*, Tokyo. (*in* Japanese).

Kobayashi, T., 1956, An interesting new form of the Aturidae from the Paleogene of northern Kyushu. *Paleont. Soc. Japan, Trans. Proc., N.S.*, no. 23, p. 243–245, 1 fig.

————., and Masatani, K., 1955, On the occurrence of *Aturina* in provinces of Etchu and Iwami and their bearing on the paleoflumenology in the Miocene of Japan. *Ibid., N.S.*, no. 17, p. 1–4, pl. 1.

Koken, E., 1897, Die Gastropoden der Trias um Hallstadt. *Kais-kün. geol. Reichsanst., Abhandl.*, vol. 17, no. 4, 112pp., 23pls. (Wien). (*fide* Moore, R.C., 1960).

Kuroda, T., Habe, T., and Oyama, K., 1971, The sea shells of Sagami Bay. p. i-xvi, 1–741 (*in* Japanese), 1–489 (*in* English), 1–28 (index *in* Japanese), 29–51 (index *in* English), 3 figs., 121 pls., *Maruzen Book. Co.*, Tokyo.

Kuroda, H., and Urata, H., 1964, Discovery of fossils *Perotrochus* in the Miike coal-field, Kyushu, Japan. *Paleont. Soc. Japan, Trans. Proc., N.S.*, no. 55, p. 263–270, figs. 1–2 pl. 38.

Leach, W.E., 1819, A voyage of discovery in H.M.S. Isabella and Alexander (in 1818) for purpose of exploving Baffins Bay and inquiring into the probability of a north-west Passage. App. 1, II. (*non vidi.*).

Lischke, C.E., 1868–1873, Diagnosen neuer Meeres Conchylien von Japan. *Mal. Blat.*, vol. 19, no. 104 (*non vidi.*).

————., 1874, Japanische Meeres-Conchylien. Kenntniss der mollusken Japan's mit besonder Rücksicht auf die Geographische Verbertung derserben, Cassel, Verlang von Throdori Fischer. Vol. 3, p. 1–123, pls.1–9.

MacNeil, F.S., 1960, Tertiary and Quaternary Gastropoda of Okinawa. *U.S. Geol. Surv. Prof. Paper*, **339**, p. 1–148, figs. 1–17, pls. 1–21.

Moore, R.C., 1960, Treatise on Invertebrate Paleontology, Part I, Mollusca 1. 351pp., 216figs., *U.S. Geol. Surv.* and *Kansas Univ. Press.*, Kansas.

Nagao, T., 1928, Palaeogene fossils of the island of Kyushu, Japan. *Tohoku Imp. Univ., Sci. Rep., Sec. Ser.*, vol. 9, no. 3, p. 97–128, pls. 18–22.

Niino, H., 1934, The bottom sediments of the western part of Tsugaru Strait. *Geol. Soc. Japan, Jour.*, vol. 41, no. 495, p. 713–723, figs. 1–5, tabs. 1–5. (*in* Japanese).

————., 1935, On the soundings from the banks between the Oga Peninsula and Sado Islands, in the northern part of Japan Sea. *Imp. Fish. Inst., Jour.*, vol. 31, no. 1, p. 1–33, figs. 1–4, tabs. 1–9, pls. 1–7.

————., 1950, On the bottom deposits on the banks at the mouth of Wakasa Bay and on the adjacent continental shelf. *Tokyo Univ. Fisheries, Jour.*, vol. 37, no. 1, p. 1–274, figs. 1–65, tabs. 1–38, pls. 1–3.

Noda, H., 1969, Fossils from the Shiiya Formation in Niigata Prefecture with special reference to the genus *Turcicula*. *Fossils*, no. 17, p. 22–28, fig. 1, 1 tab. (*in* Japanese).

Nomura, S., 1940, Mollusca dredged by the Husa-maru from the Pacific coast of Tiba Prefecture, Japan. *Oceanogr. Works in Japan, Rec.*, vol. 12, no. 1, p. 81–116, pl. 11.

————., and Hatai, K., 1940, The marine fauna of Kyurokushima and its vicinity, northeast Honsyu, Japan. *Saito Ho-on Kai Mus., Res. Bull.*, no. 19, p. 57–115, pls. 3–4.

————., and Niino, H., 1940, Mollusca dredged from off the coast of Hukui Prefecture in the Japan Sea. *Oceanogr. Works in Japan, Rec.*, vol. 12, no. 1, p. 23–79, pl. 1.

Okada, K., 1965, New illustrated encyclopedia of the fauna of Japan — Mollusca — 326pp., 1225 figs. *Hokuryukan Pub. Co., Litd.*, Tokyo. (*in* Japanese).

————., and Taki, I., 1960, Encyclopedia zoologia illustrated in colours, vol. 3. 200pp., 91pls., 66 pp. (index), *Hokuryukan Pub., Co. Litd.*, Tokyo. (*in* Japanese).

Okutani, T., 1964, Report on the archibenthal and abyssal gastropod Mollusca mainly collected from Sagami Bay and adjacent waters by the R.V. Sôyô-Maru, during the years 1955–1963. *Univ. Tokyo, Fac. Sci., Jour., Sec.* **2**, vol. 15, pt. 3, p. 371–447, pls. 1–7.

————., 1966, Archibenthal and abyssal Mollusca collected by the R.V. Sôyô-Maru from Japanese waters during 1964. *Tokai Reg. Fisher., Res. Lab., Bull.*, no. 46, p. 1–32, pls. 1–2.

————., 1968a, Systematics, ecological distribution and paleoecological implication of archibenthal and abyssal Mollusca from Sagami Bay and adjacent areas. *Univ. Tokyo, Fac. Sci., Jour., Sec.* **2**, vol. 17, pt. 1, p. 1–98, figs. 1–43, tabs. 1–28, pl. 1.

————., 1968b, Bathyal and abyssal Mollusca trawled from Sagami Bay and the south off Boso Peninsula by the R.V. Sôyô-Maru, 1965–1967. *Tokai Reg. Fisher., Reg. Lab., Bull.*, no. 56, p. 7–54, figs. 1–6, pls. 1–3.

Oldroyd, I.S., 1927, The marine shells of the west coast of North America. *Stanford Univ. Publ. Geol. Sci.*, vol. 2, pt. 3, p. 1–339, pls. 73–108.

Oyama, K., 1950, Studies of fossil molluscan biocoenosis, no. 1. Biocoenological studies on the Mangrove Swamps, with descriptions of new species from Yatuo Group. *Geol. Surv. Japan, Rep.*, no. 132, p. 1–15, 1 fig., pls. 1–3.

————., Mizuno, A., and Sakamoto, T., 1960, Illustrated handbook of Japanese Paleogene Mollusca. *Geol. Surv. Japan*, p. 1–244, figs. 1–3, tabs. 1–7, pls. 1–244.

Ozaki, H., 1958, Stratigraphical and paleontological studies on the Neogene and Pleistocene formations of the Tyosi district. *Nat. Sci. Mus., Bull.*, vol. 4, no. 1, p. 1–182, figs. 1–16, tabs. 1–2,

maps 1–3, pls. 1–24.

Palmer, K.W. van, 1958, Type specimens of marine mollusca described by P.P. Carpenter from the west coast (San Diego to British Columbia). *Geol. Soc. Amer., Mem.* **76**, p. 1–376, pls. 1–34.

Parker, R.H., 1964, Zoogeography and ecology of macro-invertebrates of Gulf of California and continental slope of western Mexico. A Symposium marine geology of the Gulf of California. *Amer. Assoc. Petrol. Geol., Mem.* 3, p. 331–376, 21 figs., 2 tabs., pls. 1–9.

Pilsbry, H.A., 1889, Trochidae, Stomatiidae, Pleurotomaridae, Haliotidae. *Man. Conch.*, vol. 11, p. 1–519, pls. 1–67.

————., 1893a, A new trochid from Japan. *Nautilus*, vol. 6, no. 9, p. 105–106, fig. 3, on pl. 2.

————., 1893b, Illustrations of new species of shell. *Ibid.*, vol. 6, no. 12, p. 133, pl. 2.

————., 1895, Catalogue of the marine mollusks of Japan with descriptions of new or others collected by Fredrich Stearns. p. 1–196, pls. 1–11. Published by F. Stearns, Detroit.

Ravn, J.P., 1933, Études sur les Pélecypodes et Gastropodes Danies du calcaire de Faxe. *Acad. Roy. Sci. Latt. Demmark, Mem., Sec. Sci.*, **9** *me, ser. t. v.*, no. 2, p. 1–70, pls. 1–7.

Rehder, H.A., 1955, The genus *Turcicula*. *Malac. Soc. London, Proc.*, vol. 31, pts. 5–6, p. 222–225, pl. 12.

Schepman, M.M., 1905, The adult state of *Bathybembix aeola* Watson. *Leyden Mus., Notes*, vol. 25, no. 3, p. 100–102. (*non vidi.*)

Shikama, T., 1962, On some noteworthy shells from off Choshi, Chiba Prefecture. *Yokohama Nat. Univ., Sci. Rep., Sec.* **2**, no. 8, p. 29–56, pl,. 1–3.

————., 1973, Molluscan assemblages of the basal part of the Zushi Formation in the Miura Peninsula. *Tohoku Univ., Sci. Rep., Sec. Ser., Geol., Spec. Vol.*, no. 6 (*Hatai Mem. Vol.*), p. 179–204, figs. 1–10, tabs. 1–4, pls. 16–17.

————., and Horikoshi, M., 1963, Selected shells of the worlds illustrated in colours. 154 pp., 102 pls., 211 figs., *Hokuryukan Pub. Co. Litd.*, Tokyo. (*in* Japanese).

————., and Masujima, A., 1969, Quantative studies of the molluscan assemblages in the Ikego-Nojima formations. *Yokohama Nat. Univ., Sci. Rep., Sec.* **2**, no. 15, p. 61–94, figs. 1–18, tabs. 1–10, pls. 5–7.

Shuto, T., 1961, Paleontological study of the Miyazaki Group — A general account of the faunas — *Kyushu Univ., Fac. Sci., Mem., Ser. D, Geol.*, vol. 10, no. 2, p. 73–206, figs. 1–23, tabs. 1–5, pls. 11–13.

Smith, A.G., and Gordon, M. Jr., 1948, The marine mollusks and brachiopods of Monterey Bay, California and vicinity, California. *Acad. Sci. California, Proc., Ser.* **4**, vol. 26, no. 8, p. 147–245, figs. 1–4, pls. 3–4.

Takai, F., 1950, *Amynodon watanabei* from the Latest Eocene of Japan with a brief summary of the Latest Eocene mammalian faunule in eastern Asia. *Geol. Surv. Japan, Rep.*, no. 131, p. 1–14, tabs. 1–2, pl. 1.

Takeda, H., 1953, The Poronai Formation (Oligocene Tertiary) of Hokkaido and South Sakhalien and its fossil fauna. *Hokkaido Assoc. Coal. Mining Tech. Geol. Sec.*, no. 3, p. 1–103 (*in* English), p. 1–45 (*in* Japanese), figs. 1–18, tabs. 1–5, pls. 1–13.

Taki, I., and Otuka, Y., 1943, Genus *Turcicula* Dall. *Conch. Asiatica*, vol. 1, no. 3, p. 93–108, figs. 1–6, pls. 1. (*in* Japanese).

————., and Oyama, K., 1954, Matajiro Yokoyama's The Pliocene and later faunas from the Kwanto region in Japan. *Palaeont. Soc. Japan, Spec. Pap.*, no. 2, p. 1–68, pls. 1–49.

Taylor, G.W., 1895, Preliminary catalogue of the marine Mollusca of the Pacific coast of Canada with noted upon their distribution. *Roy. Soc. Canada, Proc. Trans., Ser.* **2**, vol. 1, p. 17–100.

Thiele, J., 1931, Handbuch der systematic weichtierkunde. p. 1–778, figs. 1–783, *Jena Verlag von Gustav, Fischer*, Jena.

Tsuchi, R., 1955, The paleo-ecological significance of the later Pliocene molluscan fauna from the Kakegawa district, the Pacific coast of central Japan. *Shizuoka Univ., Lib. Arts, Fac., Nat. Sci., Rep.*, no. 8, p. 45–58, pl. 1.

————., 1956, The ecological distribution of marine Mollusca living in the coast of Shizuoka Prefecture, the Pacific side of central Japan – As a basis of paleoecology — . *Ibid.*, no. 10, p. 17–24, figs. 1–4.

————., 1958, A note on Mollusda dredged from Suruga Bay, the Pacific side of central Japan. *Ibid.*, vol. 2, no. 2, p. 69–76, 9 figs., pls. 1–2.

Tsuda, K., 1959, New Miocene molluscs from the Kurosedani Formation in Toyama Prefecture,

Japan. *Niigata Univ., Fac. Sci., Jour., Ser.* **2**, vol. 3, no. 2, p. 67–110, fig. 1, pls. 1–7.

————., 1960, Paleo-ecology of the Kurosedani fauna. *Ibid.*, vol. 3, no. 4, p. 171–203, figs. 1—27, 1 table.

Watson, R.B., 1878, Mollusca of H.M.S. Challenger Expedition, III. Torchidae, viz. the genera *Seguenzia*, *Basilissa*, *Gaza* and *Bembix*. *Linn. Soc. London, Jour., Zoology*, vol. 14, p. 586–605. (*non vidi.*)

————., 1886, Report of the Scaphopoda and Gastropoda collected by H.M.S. Challenger during the years 1873–1876. *Res. Voy. Challenger, Rep. Sci., Zoology*, vol. 15, p. 1–722, pls. 1–50.

Wenz, W., 1938, Gastropoda, Teil 1. Allgemeiner teil und Prosobranchia. Handb. Paleont., 948, pp., 2764 figs., *Verlag. Gebrüder Borntrager*, Berlin.

Williamson, M.B., 1892, An annoted list of the shells of San Pedro Bay and vicinity with a description of two new species by W.H. Dall. *U.S. Nat. Mus., Proc.*, vol. 15, no. 1892, p. 179–220, pls. 19–23.

Yamakawa, M., 1934, [Illustrations of Mollusca in natural colours in Japan]. (*fide* Taki and Otuka, 1943).

Yokoyama, M., 1911, Some Tertiary fossils from the Miike coal-field. *Imp. Univ. Tokyo, Coll. Sci., Jour.*, vol. 27, art. 20, p. 1–16, pls. 1–3.

————., 1920, Fossils from the Miura Peninsula and its immediate north. *Ibid.*, vol. 39, art 6, p. 1–193, pls. 1–18.

————., 1925, Molluscan remains from the uppermost part of the Jo-ban coal-field. *Ibid.*, vol. 45, art. 5, p. 1–34, pls. 1–6.

————., 1928, Neogene shells from the oil field of Higashiyama, Echigo. *Imp. Univ. Tokyo, Fac. Sci., Jour., Sec.* **2**, vol. 2, pt. 7, p. 351–362, pls. 68–69.

Plates 9—12

Plate 9

(All figures in natural size unless otherweise stated)

Figs. 1–3, 11–12, *Turcicula* (*Ginebis*) *argenteonitens argenteonitens* (Lischke), p. 71, off Kochi, Recent, IGPS coll. cat. no. 91756.

Fig. 4, *Turcicula* (*Convexia*) *convexiuscula* (Yokoyama), p. 76, off Kochi, Recent, IGPS coll. cat. no. 91755.

Fig. 5, *Turcicula* (*Convexia*) *convexiuscula* (Yokoyama), p. 76, Pliocene Sukegawa Formation, IGPS coll. cat. no. 17257. Loc. Sea-side cliff at Sukegawa, Hitachi City, Ibaraki Prefecture.

Figs. 6, 9, 15, *Turcicula* (*Ginebis*) *hataii* Noda, n. sp., p. 73, off Kinka-san, Miyagi Prefecture, IGPS coll. cat. no. 17149 (Holotype).

Figs. 7, 13, *Turcicula* (*Turcicula*) *crumpi* (Pilsbry), ×2, p. 61, Pleistocene Narita Formation, IGPS coll. cat. no. 24051, Loc. Small river side cliff, south of Shiromawari, Tsurumaicho, Ichihara-gun, Chiba Prefecture.

Figs. 8, 10, *Turcicula* (*Turcicula*) *crumpi* (Pilsbry), × 2, p. 61, Korean Strait, Korea, Recent, IGPS coll. cat. no. 55344.

Figs. 14, 18, *Turcicula* (*Ginebis*) *argenteonitens argenteonitens* (Lischke), p. 71, Pleistocene Sanuki Formation, IGPS coll. cat. no. 46293, Loc. Sea side cliff, at Sasage, Osawa-cho, Kimitsu-gun, Chiba Prefecture.

Figs. 16, 20, 21, *Turcicula* (*Turcicula*) *tsudai* Noda, n. sp., p. 66, Late Miocene Shiiya Formation, Holotype (Figs. 16, 20, IGPS coll. cat. no. 91753), Paratype (Fig. 21, × 2, IGPS coll. cat. no. 91758), Loc. River side cliff of Nishidani-gawa, about 200m south of Hanzogane, Tochio City, Niigata Prefecture.

Fig. 17, *Turcicula* (*Bathybembix*) *bairdi* (Dall), p. 68, off San Clemente, Recent, IGPS coll. cat. no. 2209.

Fig. 19, *Turcicula* (*Ginebis*) *nagaoi* Noda, n. sp., p. 74, Eocene Kattachi Formation, Holotype, IGPS coll. cat. no. 35773. Loc. Northen foot of Hakamadake, Manda, Arao City, Kumamoto Prefecture.

Figs. 22, 23, *Turcicula* (*Ginebis*) *sukegawaense* Noda, n. sp., p. 75, Pliocene Sukegawa Formation, IGPS coll. cat. no. 91750 (Paratype), Loc. Sea cliff at Hatsuzaki, Hitachi City, Ibaraki Prefecture.

Fig. 24, *Turcicula* (*Ginebis*) *argenteonitens hirasei* Taki and Otuka, p. 72, off Sanriku, Recent, IGPS coll. cat. no. 91757.

Abbreviations used in the explanation to plate are;

IGPS cll. cat. no.=Catalogued number of specimens preserved in the collection of the Institute of Geology and Palentology, Faculty of Science, Tohoku University.

CM=Specimens preserved in the collection of the Tokyo University.

JC=Specimens preserved in the collection of the Kyoto University.

MCZ=Specimens collected in the collection of the Museum of Comparative Zoology, Harvard University.

U.S. Nat. Mus.=Specimens collected in the collection of the National Museum of United States of America.

UH=Specimens preserved in the collection of the Hokkaido University.

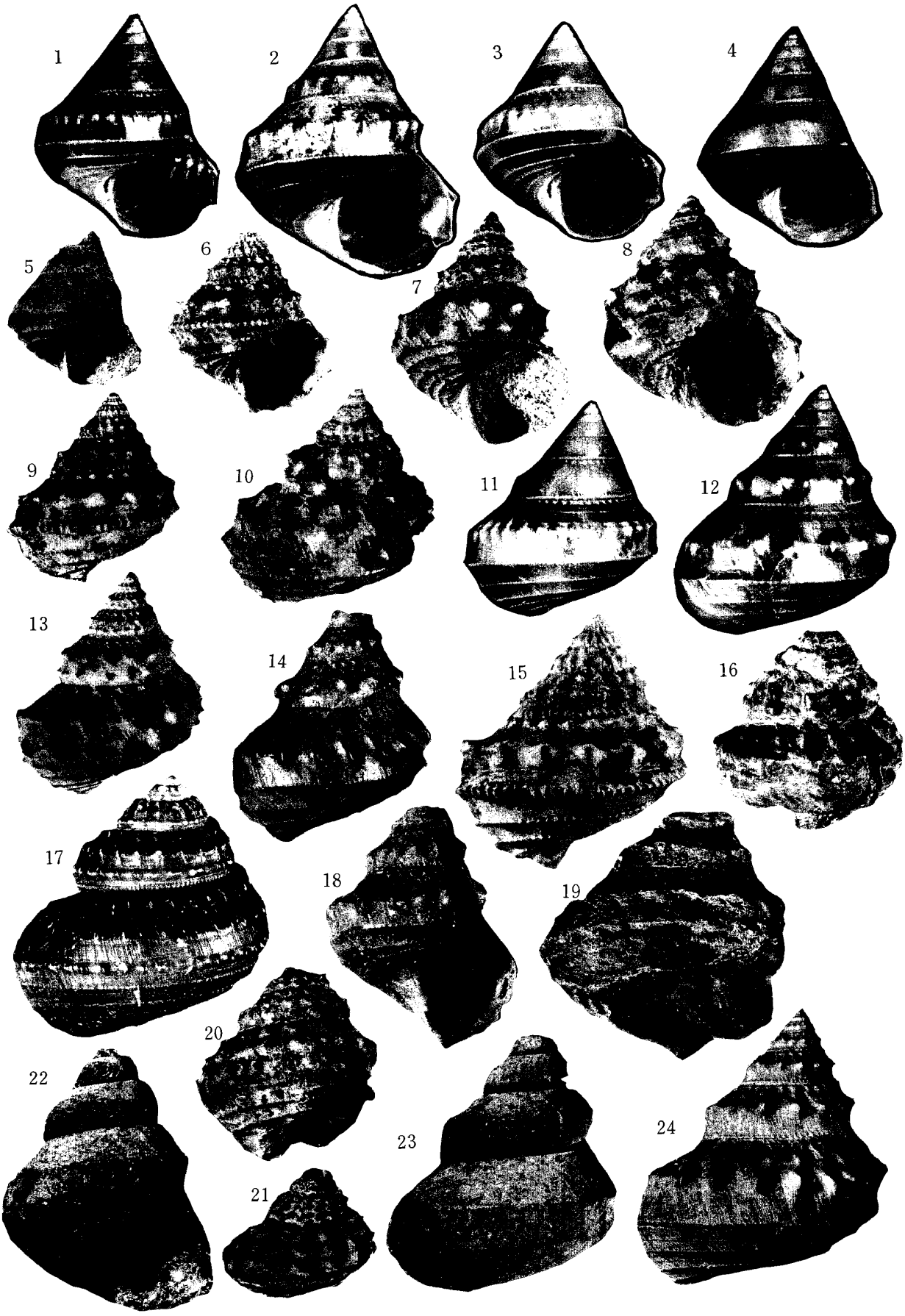

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Plate 10

(All figures in natural size unless otherwise stated)

Figs. 1–2, *Turcicula* (*Turcicula*) *crumpi yokoyamai* Otuka, p.63, Reproduction of Otuka *in* Taki and Otuka, 1943, Pliocene Urago Formation, Kanagawa Prefecture. Fig. 1 (Paralectotype. CM 20271), Fig. 2 (Lectotype, CM 20270).

Figs. 3, 9, 22, *Turcicula* (*Turcicula*) *osawanoensis* (Tsuda), p.65, Reproduction of Tsuda (1959), Middle Miocene Kurosedani Formation, Toyama Prefecture. Holotype, JC1400031.

Fig. 4, *Turcicula* (*Ginebis*) *argenteonitens argenteonitens* (Lischke), p.71, Late Miocene Mamurogawa Formation, IGPS coll. cat. no. 91754, Loc. Jobuchi, Mamurogawa-machi, Mogami-gun, Yamagata Prefecture.

Fig. 5, *Turcicula* (*Turcicula*) *crumpi* (Pilsbry), p.61, Reproduction of Pilsbry (1893a), Japan, Recent.

Fig. 6, *Turcicula* (*Ginebis*) *nagaoi* Noda, n. sp., p.74, Eocene Kattachi Formation, IGPS coll. cat. no. 35773 (Holotype), Loc. Same to Pl. 9, fig. 19.

Fig. 7, *Turcicula* (*Turcicula*) *japonica* (Dall), p.64, Reproduction of Dall (1925), Uraga Strait, Japan, U.S. Nat. Mus. cat. no. 205752 (Lectotype).

Figs. 8, 21, *Turcicula* (*Turcicula*) *imperialis* (Dall), p.63, Reproduction of Wenz (1938), off Cuba, Recent, Holotype, MCZ cat. no. 7575.

Fig. 10, *Turcicula* (*Bathybembix*) *bairdi* (Dall), p.68, off San Clemente, Recent, IGPS coll. cat. no. 2209.

Figs. 11, 12, *Turcicula* sp., p.77, Pliocene of Sakhalin, IGPS coll. cat. no. 26311, Loc. Down-stream side cliff of Kisen-gawa, Shimizu, South Sakhalin.

Fig. 13, *Turcicula* (*Ginebis*) *sukegawaense* Noda, n. sp., p.75, Pliocene Sukegawa Formation, IGPS coll. cat. no. 26634, Holotype, Loc. Sukegawa, Hitachi City, Ibaraki Prefecture.

Figs. 14, 24, *Turcicula* (*Ginebis*) *argenteonitens hirasei* Taki and Otuka, p.72, off Sanriku, Recent, IGPS coll. cat. no. 91757.

Fig. 15, *Turcicula* (*Ginebis*) *sakhalinensis* Takeda, p.75, Eocene Poronai Formation, Loc. 4080 m east of the junction of Ist tributary with Okô River, Honto-gun, South Sakhalin, Reproduction of Takeda (1953), UH, 11101, Holotype.

Figs. 16, 17, *Turcicula* (*Bathybembix*) *aeola* (Watson), p.67, Late Miocene Nobori Formation, IGPS coll. cat. no. 91752, Loc. Nobori, Hane-mura, Aki-gun, Kochi Prefecture.

Fig. 18, *Turcicula* (*Convexia*) *convexiuscula* (Yokoyama), p.76, off Kochi, Kochi Prefecture, IGPS coll. cat. no. 91755.

Figs. 19, 20, Umbilical view of *Turcicula* (*Turcicula*) *crumpi* (Pilsbry), × 2, p.61, see Pl. 9, figs. 7, 13.

Fig. 23, Umbilical view of *Turcicula* (*Turcicula*) *tsudai*, n. sp., (Holotype), p.66, see Pl. 9, figs. 16, 20.

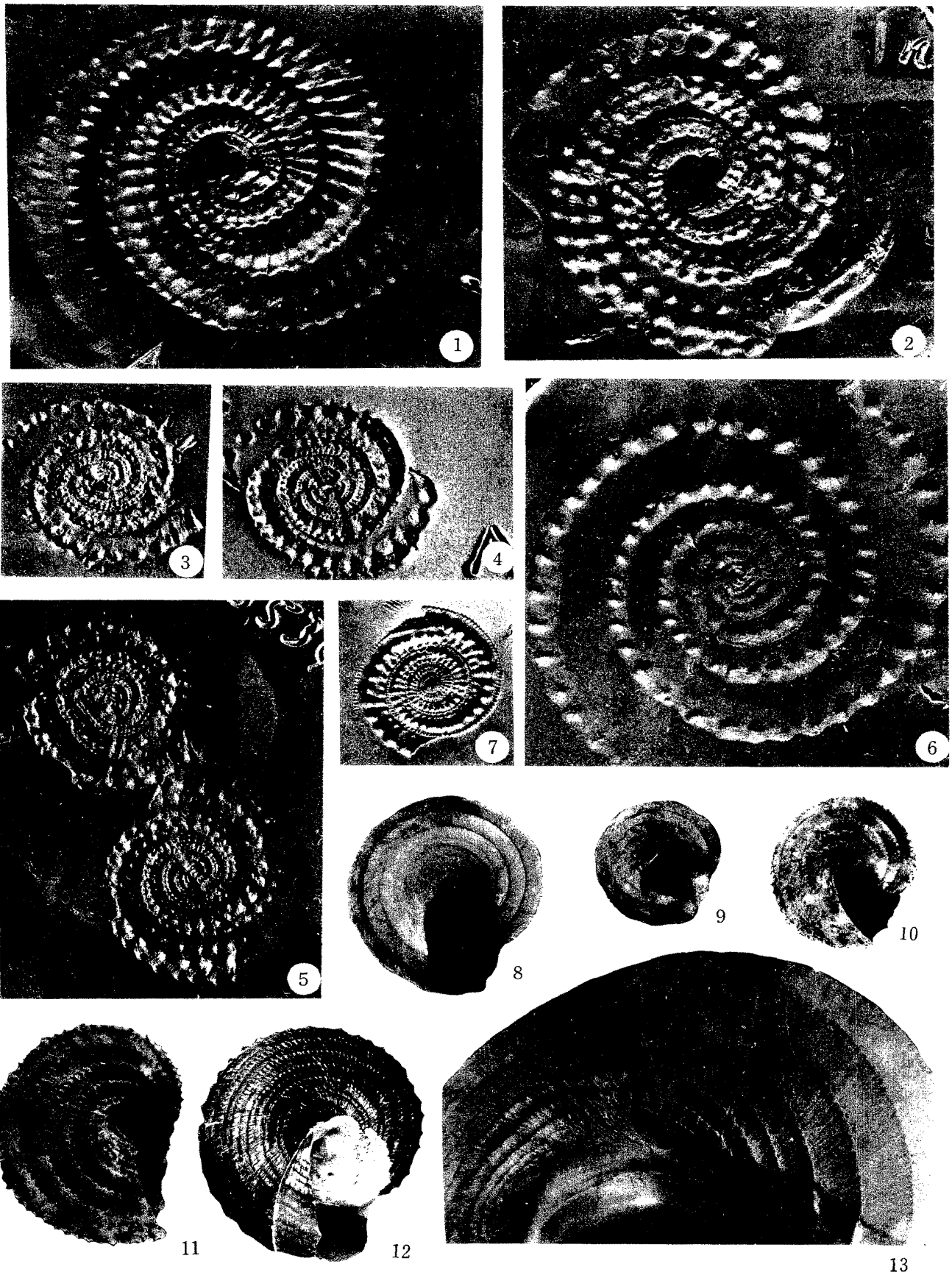
Plate 11

(All figures in natural size)

Fig. 1, Rotated track of *Turcicula* (*Convexia*) *convexiuscula* (Yokoyama), p.76, off Kochi, Kochi Prefecture, Recent, IGPS coll. cat. no. 91755, see Pl. 10, fig. 18.

Figs. 2, 4, 6, Rotated tracks of *Turcicula* (*Ginebis*) *argenteonitens argenteonitens* (Lischke), p.71, off Kochi, Kochi Prefecture, Recent, IGPS coll. cat. no. 91756.

Figs. 3, 5, Rotated tracks of *Turcicula* (*Ginebis*) *argenteonitens hirasei* Taki and Otuka p.72, off Sanriku., Recent, IGPS coll. cat. no. 91757, see Pl. 9, fig. 24.



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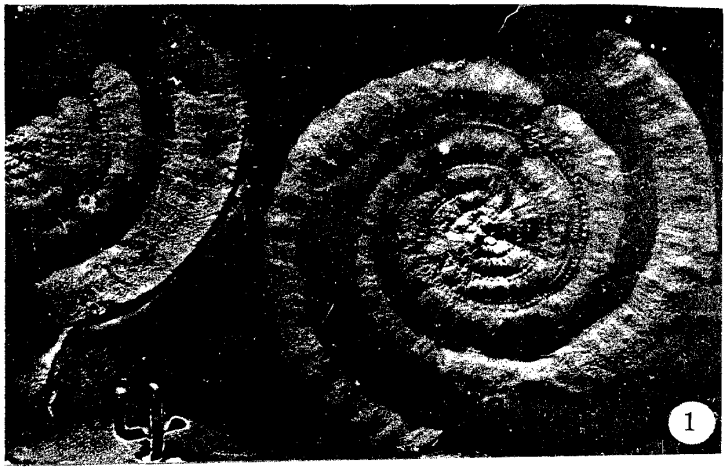

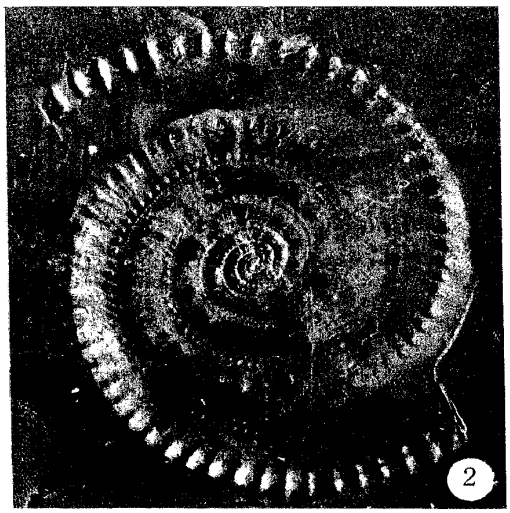

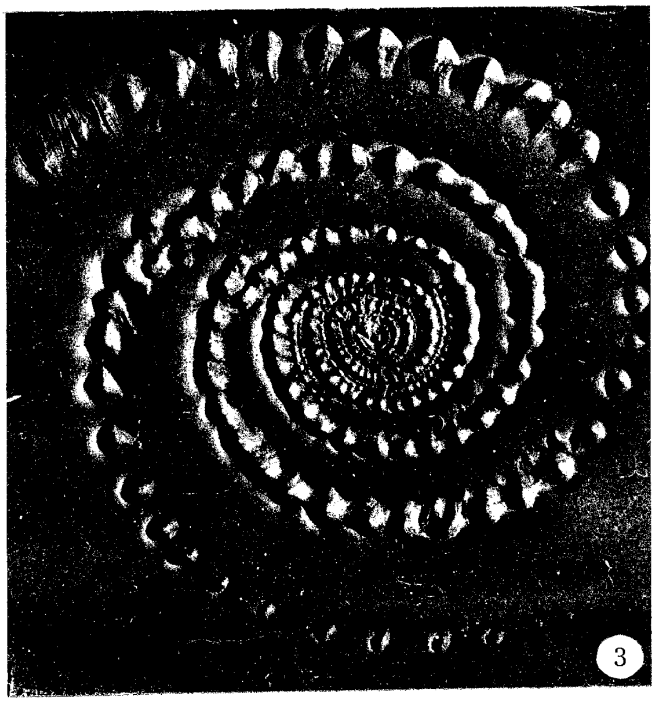

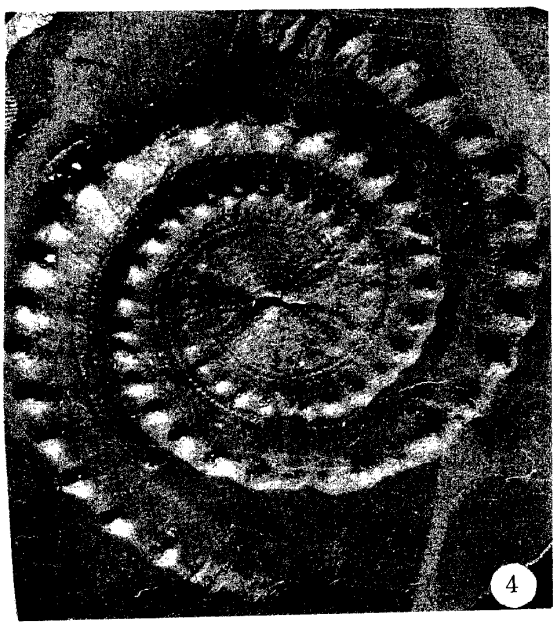

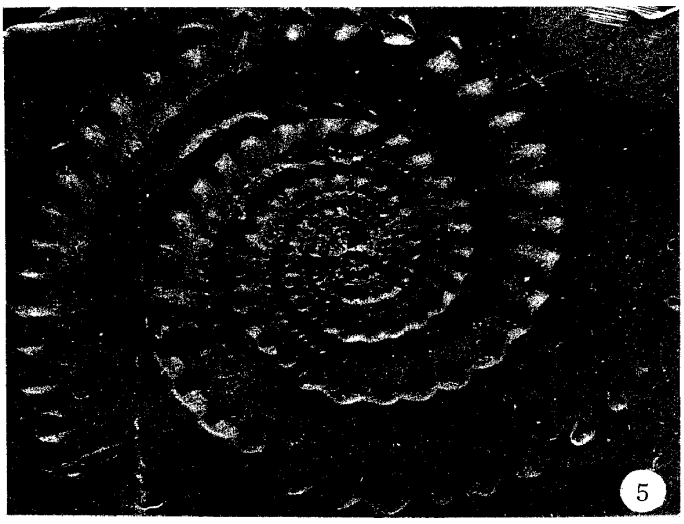

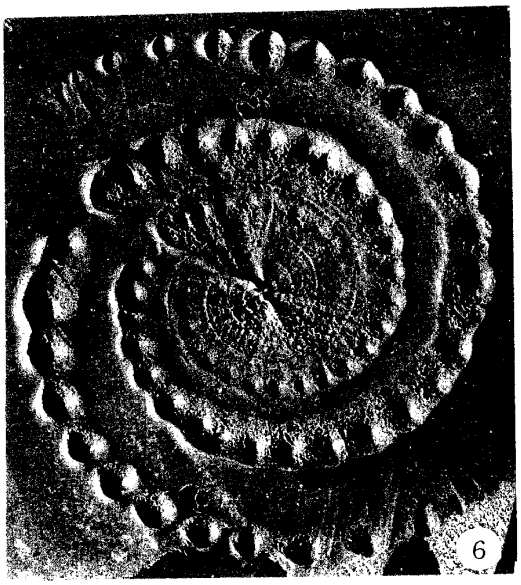

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Plate 12

(All figures in natural size unless otherwise stated)

Fig. 1, Rotated track of *Turcicula* (*Bathybembix*) *bairdi* (Dall), p.68, off San Clemente, Recent, IGPS coll. cat. no. 2209, see Pl. 9, fig. 17.

Fig. 2, Rotated track of *Turcicula* (*Turcicula*) *tsudai* Noda, n. sp., p.66, Late Miocene Shiiya Formation, Holotype, IGPS coll. cat. no. 91753, see Pl. 9, figs. 16, 20.

Figs. 3, 5, Rotated tracks of *Turcicula* (*Turcicula*) *crumpi* Pilsbry, p.61, Korean Strait, Recent, IGPS coll. cat. no. 55344, see Pl. 9, figs. 8, 10.

Fig. 4, Rotated track of *Turcicula* (*Turcicula*) *crumpi* (Pilsbry), p.61, Pleistocene Narita Formation, IGPS coll. cat. no. 24051, see Pl. 9, figs. 7, 13.

Fig. 6, Rotated track of *Turcicula* (*Ginebis*) *argenteonitens argenteonitens* (Lischke), p.71, off Kochi, Kochi Prefecture, Recent, IGPS coll. cat. no. 91756.

Fig. 7, Rotated track of *Turcicula* (*Ginebis*) *hataii* Noda, n. sp., p.73, off Kinka-san, Miyagi Prefecture, Recent, IGPS coll. cat. no. 17149 (Holotype), see Pl. 9, figs. 6, 9, 15.

Fig. 8, 13, Umbilical view of *Turcicula* (*Ginebis*) *argenteonitens hirasei* Taki and Otuka p.72, showing the secondary spiral striations, Fig. 13, × 2, off Sanriku, Recent, IGPS coll.cat. no. 91757.

Fig. 9, Umbilical view of *Turcicula* (*Convexia*) *convexiuscula* (Yokoyama), p.76, Pliocene Sukegawa Formation, IGPS coll. cat. no. 17257, Loc. Sea side cliff of south of Tsurushi-zaki, Hitachi City, Ibaraki Prefecture.

Figs. 10–11, Umbilical view of *Turcicula* (*Ginebis*) *hataii* Noda, n. sp., p.73, off Kinka-san, Miyagi Prefecture, Recent, IGPS coll. cat. no. 17149, Holotype, see Pl. 9, figs. 6, 9, 15.

Fig. 12, Umbilical view of *Turcicula* (*Bathybembix*) *bairdi* (Dall), p.68, off San Clemente, Recent, IGPS coll. cat. no. 2209, see Pl. 9, fig. 17.