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Faunal affinity of Toarcian-Aalenian (Early Jurassic) bivalves from Mae Sot and Umphang (Tak Province), Northwestern Thailand

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ABSTRACT: In the Mae Sot and Umphang areas (NW Thailand), Jurassic strata seal the Permian and Triassic substratum of the Shan-Thai terrane with a brecciated conglomerate. Pliensbachian to Early Bajocian shallow marine strata are intercalated within the partly terrestrial Jurassic sequence. Thirty-five Toarcian-Aalenian bivalve species from Mae Sot and Umphang were identified. Among these, *Eomiodon chumphonensis* Hayami is known only from Thailand, whereas *Parvamussium donaiense* (Mansuy), *Myophoriella saurini* Hayami, *Thracia loducensis* Hayami, *Pholadomya (Bucardiomya) fontainei* Hayami, *Thracia loducensis* Hayami and *Modiolus sestiniae* Hayami were originally described in Vietnam. *M. sestiniae* also occurs in Iran. The greater part of the fauna, however, shows varying degrees of affinity with Myanmar (6 species), Cutch (10 species), Japan (13 species) and Europe (9 species), Levant (2 species). In view of these, it appears that these highly endemic Toarcian-Aalenian bivalves from Thailand characterize the Southeastern Asian Province of Tethys.

Key words: Toarcian-Aalenian, Jurassic, marine bivalves, Thailand, SE Asian Province

1. INTRODUCTION

Jurassic shallow-marine deposits are widely distributed in Southeast Asia. Marine bivalves have been described from Myanmar (Healey, 1908; Reed, 1931, 1936), Thailand (Hayami, 1960; Meesook, 1994; Meesook and Grant-Mackie, 1994, 1996, 1997), Laos and Vietnam (Counillon, 1909; Mansuy, 1914; Saurin, 1935; Hayami, 1964; Hayami, 1972) (Fig. 1). The facies of these marine formations contribute to the understanding of the environmental changes that took place after closure of the Paleotethys and help unravel the paleobiogeography of the southeast Asian Tethys. In Thailand, Jurassic marine formations cover wide areas of the freshly consolidated Shan-Thai terrane. These extend from Mae Hong Son in northwestern Thailand to the Kanchanaburi basin in Western Central Thailand, and in Peninsular Thailand from Chumphon in its northern part to Nakhon Si Thammarat in the south. The first description of bivalves from Thailand goes back to Hayami (1960), who described two species, including one new species. These were regarded Pliensbachian to Aalenian in age by Meesook and Grant-Mackie (1994, 1996). Meesook (1994) undertook a systematic review of Jurassic bivalves of Thailand at the generic level, and Meesook and Grant-Mackie (1997) recognized several faunal associations and paleo-environments. The detailed taxonomic study of the Jurassic bivalves from Thailand is only at its beginning. The only other bivalve investigation in the region is that of Hayami (1972) on the marine Toarcian bivalves of Vietnam.

The present paper is based on the Jurassic bivalves of the Mae Sot and Umphang areas in northwest Thailand. The preliminary results will shed light on the correlation of the Jurassic bivalves in Southeast Asia.

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2. GEOLOGICAL SETTING

Southeast Asia is generally divided into three tectonic terranes, i.e. Indo-Burma, Shan-Thai and Indochina. The Shan-Thai and Indochina terranes spread over Thailand. Marine Jurassic deposits in Thailand cover only areas of the Shan-Thai Terrane. The Jurassic strata in northwestern Thailand is composed regionally of the Huai Pong Group in the Mae Hong Son area, the Huai Fai Group in the Mae Sot area and the Umphang Group in the Umphang area (Meesook and Grant-Mackie, 1996).

At Mae Sot and Umphang (Fig. 2), the Jurassic strata seal the Permian - Triassic substratum of the Shan-Thai terrane. Starting with a conglomerate of brecciated nature at the base of the sequence (Ishida et al., 2004), the Jurassic sequence is mostly continental with substantial marine intercalations. These intercalations range from the Toarcian to the Early Bajocian. The latter age is based on ammonite evidence showing that marine conditions were still maintained during the Lower Bajocian, before the emersion of Shan Thai. The corals are of Tethyan affinity (Fontaine and Suteethorn, 1988). The large benthic foraminifera and algae provide clues for a wide subtropical to tropical latitudinal range (Elliot, 1983).

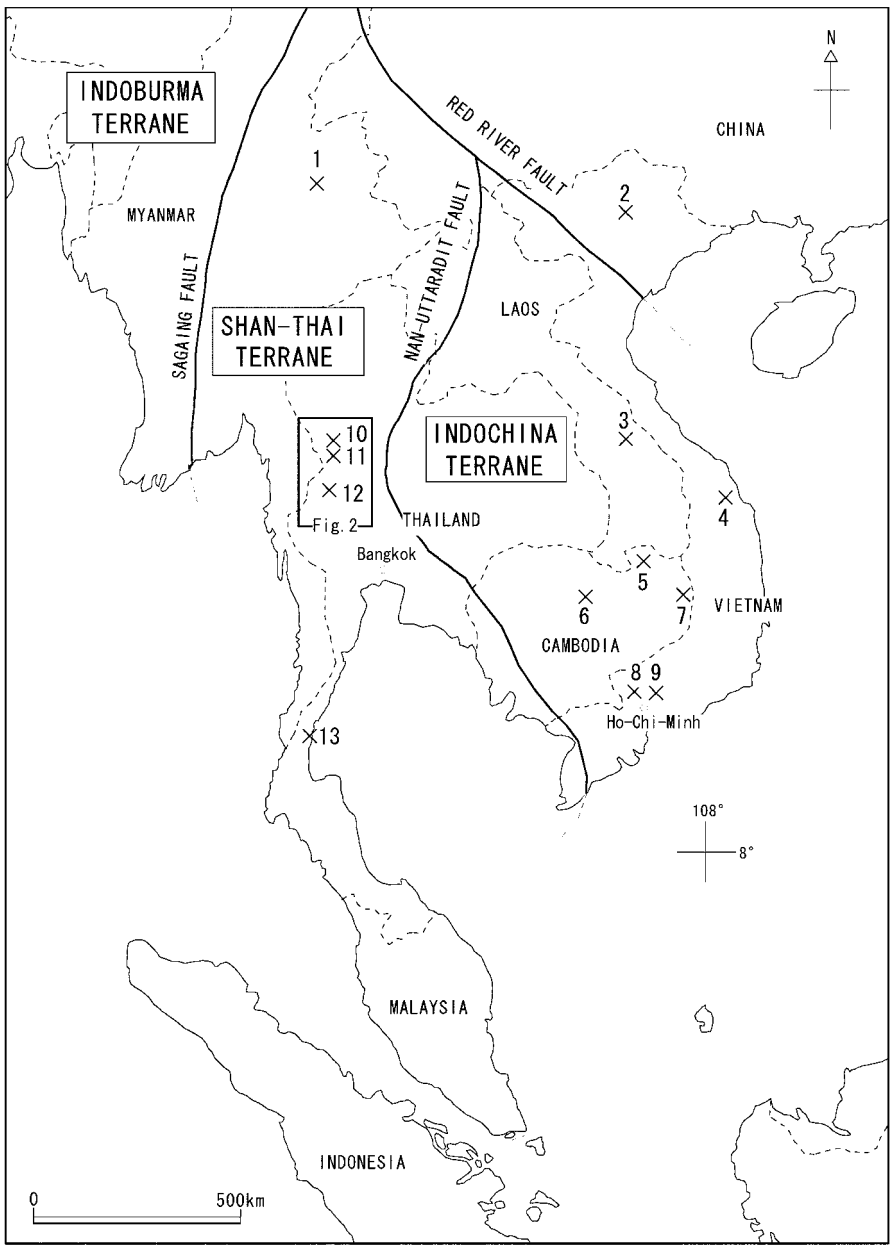

Fig. 1. Map showing the localities of Early Jurassic bivalves in southeast Asia (modified after Hayami, 1960, 1972; Reed, 1936; Healey, 1908), 1: Rhaetian-Lower Lias, Bathonian-Callovian or Oxfordian, 2: Hettangian or Sienemurian, 3: Early Jurassic, 4: Hettangian and/or Sinemurian, 5: Toarcian, 6: Sienemurian, 7: Toarcian, 8: Toarcian, 9: Toarcian, 10: Aalenian, 11: Toarcian, 12: Toarcian, 13: Middle or Late Jurassic.

3. JURASSIC STRATIGRAPHY

3.1. Mae Sot Basin

In the Mae Sot area, the marine Lower Jurassic **Hua Fai Group** was established and subdivided into three formations, from oldest to youngest, Khun Huai, Doi Yot and Pha De (Meesook and Grant-Mackie, 1996). The 900 m in thick Hua Fai Group is exposed 10 km east of Mae Sot along the road to the Huai Mae Sot power station and along the Huai Mae Sot stream. The group consists of limestone-marl-mudstone-dominated sequences which have yielded bivalves and ammonites macrofaunas. The basal conglomerate of the Khun Huai Formation unconformably rests on Triassic strata. The contact among the other formations is apparently conformable and the top of the group is interrupted at the fault-bounded margin of the Tertiary basin.

The **Khun Huai Formation** consists in the type section, of 140 m thick limestone-marl dominated sequences, interbedded with mudstone. About half-way between the Weir and Ban Kun Huai streams, the basal conglomerate (TM4), overlies unconformably marine Triassic strata and consists of Triassic limestone and chert fragments. Based on the ammonite *Dactylioceras* sp., the formation is dated as Early Toarcian. The upper part is conformably overlain by the Doi Yot Formation.

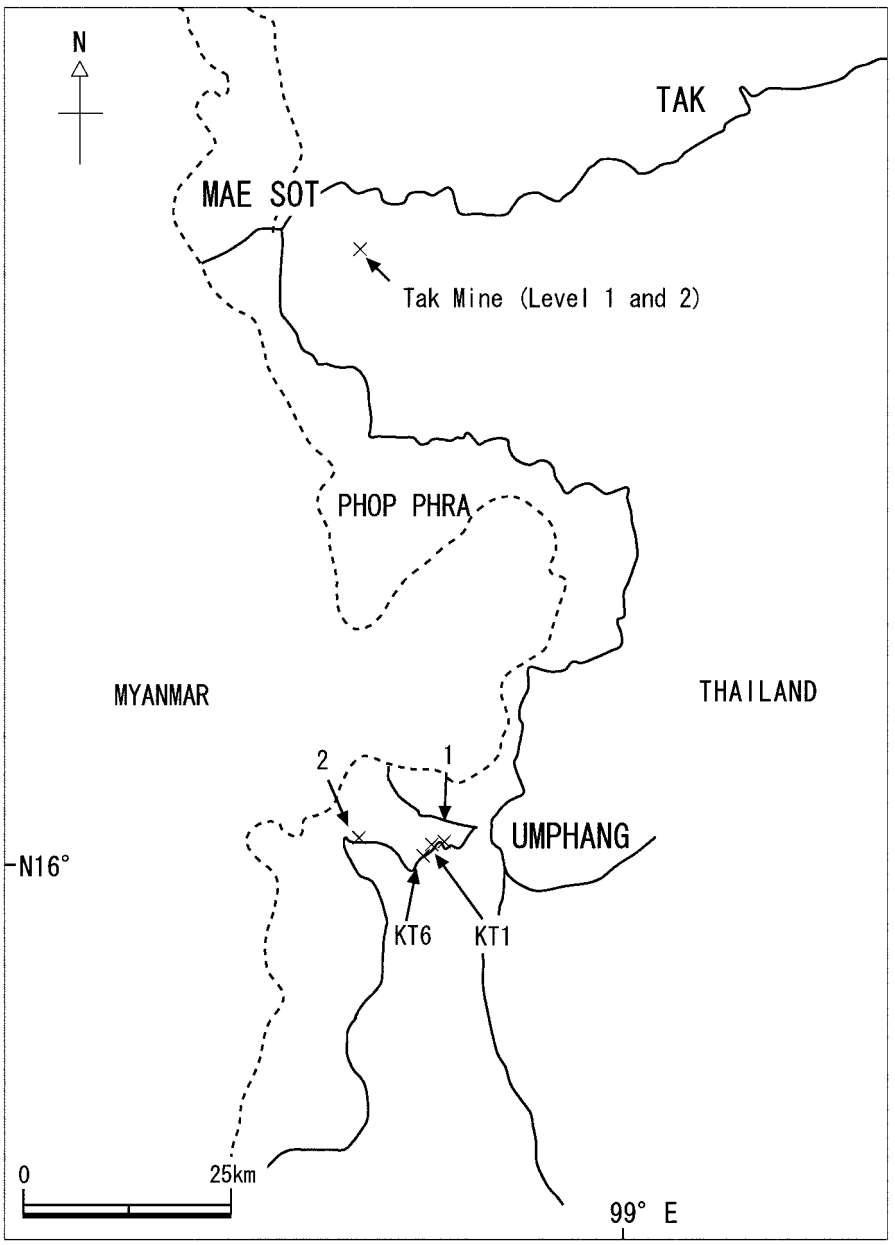

Fig. 2. Map showing the fossil localities in the Mae Sot-Umphang area. The localities numbers are the same as in Table 1.

The **Doi Yot Formation** is 370 m thick and is composed of mudstone, interbedded with limestones. Occurrence of *Onychoceras* sp., *Pseudolioceras* sp. and *Leioceras* sp. indicates a Late Early Toarcian–Early Aalenian age.

The **Pha De Formation is** 390 m thick and consists mainly of upwards thinning limestone-marl dominated sequences. A Late Aalenian–early Bajocian age is based on by the occurrence of ammonites as *Graphoceras* sp., *Eutmetoceras* sp., and *Docidoceras* sp.

3.2. Umphang Basin

In the Umphang area, the marine Lower Jurassic **Umphang Group** consists predominantly of sandstone, limestone and mudstone, subdivided into four formations, from the oldest to youngest, Klo Tho, Ta Sue Kho, Pu Kloe Khi and Lu Kloc Tu (Meesook and Grant-Mackie, 1996).

The **Klo Tho Formation** is approximately 60 m thick and consists mainly of calcareous sandstone, intercalated with dark gray, thinly bedded mudstone. The mudstone is richly fossiliferous, mostly bivalves, ammonites and plant remains. The ammonites *Dactylioceras* sp. and *Eleganticeras* sp. confer an Early Toarcian age to the formation.

The **Ta Sue Kho Formation** is approximately 105 m thick Its main lithology consists of thinly bedded, medium - to coarse-grained arkosic sandstone with plant remains. Fossils are rare.

The **Pu Khloe Khi Formation** is approximately 60 m

thick. Its lithology consists of dark gray massive to thickly bedded oncolithic limestones. Fossils are abundant and diverse consisting of corals, brachiopods, gastropods, bivalves, echinoids and the foraminifera *Timidonella* sp. and the algae *Holosporella* sp., suggesting an early Aalenian age.

The **Lu Kloc Tu Formation** consists of 200 m thick barren arkosic sandstones.

4. JURASSIC BIVALVES FROM MAE SOT AND UMPHANG (Fig. 2)

4.1. Mae Sot area

Marine bivalves mainly occur in the Khun Huai and Doi Yot formations. A short interval of the Khun Huai Formation is well exposed in the open pit of the Tak zinc mine, about 10 km east of Mae Sot, where the sequence of limestone, sandy mudstone, sandstone, oolitic limestone and alternating beds of mudstone and limestone is topped by sandstone and mudstone (Fig. 3). The Tak mine sequence has two fossiliferous levels, at 5 m and 20 m above the base repectively.

Level 1 is composed of muddy sandstone that contains ammonites, brachiopods and the marine bivalves including *Mytilus* sp. aff. *heranius* Hayami, *Modiolus sestiniae* Hayami, *Lima* sp. cf. *L. wynnei* Cox, *Lima* sp. cf. *L. callovica* Cossmann, *Entolium* sp. aff. *E. lunare* Roemer, *Bositra* sp. cf. *B. ornata* (Quenstedt), *Astarte* sp. aff. *A.deltoidea* Moberg.

Level 2 consists of a mudstone that yields *Parallelodon* sp. aff. *P. infraliassicus* Hayami, *Inoperna* sp. aff. *I. plicata* (Sowerby), *Modiolus sestiniae* Hayami, *Ostreomya* sp. cf. *O. dilata* (Phillips), *Parvamussium donaiense* (Mansuy), *Myophorella saurini* Hayami, *Trigonia* sp. aff. *T. tumida* Kitchin, *Protocardia* sp. aff. *P. contusa* Healey, *Integricardium* sp. aff. *I. hayamii* (Keen and Kasey), *Lucina* sp. aff. *L. hasei* Hayami, *Bositra* sp. cf. *B.ornata* (Quenstedt), *Astarte* sp. cf. *A. fimbriata* Walton, *Eomiodon chumphonensis* Hayami, *Opis* sp. aff. *O. tanourensis* Tamura, *Pholadomya fontainei* Hayami, *Thracia loducensis* Hayami, *Thracia* sp. aff. *T. prisca* Healey.

Hayami (1960) also found *Bositra* sp. cf. *B. ornata* (Quenstedt) at Mae Sot. At the same locality, some Aalenian ammonites were described by Sato (1961), and therefore these bivalves are regarded as Toarcian–Aalenian in age.

4.2. Umphang Area

In the Umphang area, bivalves were collected from four localities (Fig. 4). In the localities 1 and 2, the mudstone in the middle part of the Klo Tho Formation contains Toarcian marine bivalves, including *Grammatodon* sp. aff. *G. jurianus* Cox, *Arcomytilus* sp. aff. *A. laitmairensis* (de Loriol), *Inoperna* sp. aff. *I. plicata* (Sowerby), *Modiolus* sp. aff. *M. inbricatus* J. Sowerby, *Kobayashites* sp. aff. *K. hemicylindricus* Hayami, *Ostreomya* sp. cf. *O. dilata* (Phillips), *Somapecten* sp. aff. *S. kamimaensis* Kimura, *Camptonectes* sp. aff. *C. fromageti* Hayami, *Entolium* sp. aff. *E. lunare* Roemer, *Parvamussium donaiense* (Mansuy), *Plagiostoma* sp. aff. *P. tenuistriata* Münster, *Myophorella saurini* Hayami, *Trigonia* sp. aff. *T. tumida* Kitchin, *Integricardium* sp. aff. *I. hayamii* (Keen and Kasey), *Integricardium* sp. aff. *I. elliptica* (Yokoyama), *Lucina* sp. aff. *L. hasei* Hayami, *Bositra* sp. cf. *B. ornata* (Quenstedt), *Pholadomya fontainei* Hayami, *Homomya* sp. aff. *H. satoi* Hayami, *Thracia loducensis* Hayami, and *Thracia* sp. aff. *T. prisca* Healey.

The calcareous sandstone of localities KT1 and KT6, in the upper part of the Klo Tho Formation, yields the marine bivalves *Ostreomya* sp. cf. *O. dilata* (Phillips), *Entolium* sp. aff. *E. partitum* (Sowerby), *Trigonia* sp. aff. *T. elongata* Sowerby, *Geratrigonia* sp. aff. *G. kurumensis* Kobayashi, *Integricardium* sp. aff. *I. hayamii* (Keen and Kasey), *Astarte* sp. aff. *A. fimbriata* Walton, *Eomiodon* sp. aff. *E. namtuensis* Reed and *Thracia loducensis* Hayami.

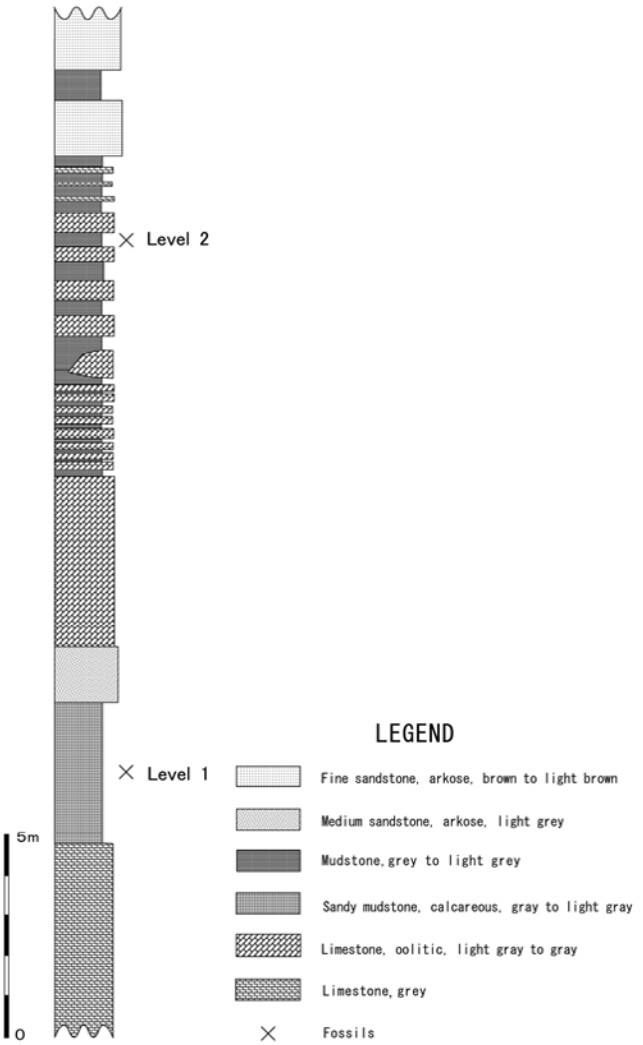

Fig. 3. Columnar section of the outcrop in the Tak Mine near Mae Sot.

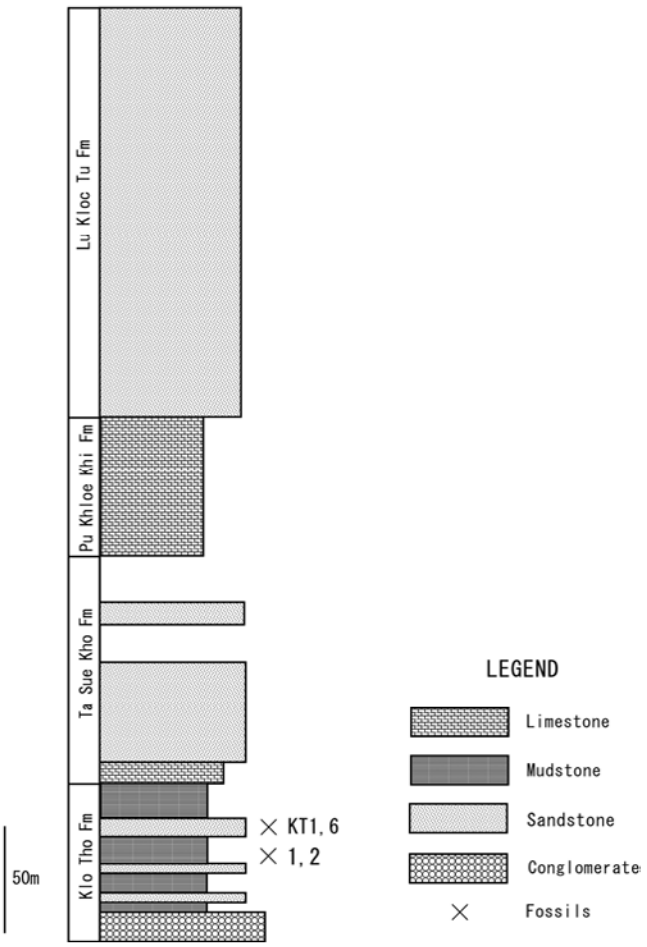

Fig. 4. Generalized columnar section of the Umphang Group (modified after Meesook and Grant-Mackie, 1996).

5. PALEOGEOGRAPHIC CONSIDERATIONS

A paleogeographic relationship exists between the 35 Toarcian–Aalenian bivalve species that were identified in the sedimentary cover of the Shan-Thai Terrane with faunas from other Early Jurassic localities in Southwest Asia (Table 1).

5.1. Vietnam

Hayami (1972) pointed out that the Toarcian bivalve fauna of Vietnam is similar to that of the western Tethyan region, although many species are endemic. The comparison between Vietnam and other parts of Asia and Europe shows a low ratio of similarity of its Early Jurassic bivalve species with that of northwestern Thailand. Only two localities yielded Early Jurassic bivalves. Earliest Jurassic strata in the Huu-Nien area of the eastern part of the Indochina Terrane, yielded probably Hettangian ammonites, From these strata Counillon (1909) and Hayami (1964) described 19 bivalve species that show no affinities to any known bivalves from Thailand. Toarcian deposits occur in southern Vietnam, near Ho-Chi-Minh, from which Mansuy (1914), Saurin (1935) and Hayami (1972) described 65 bivalve species. Eight of these, *Modiolus sestiniae* Hayami, *Ostreomya* sp. cf. *O. dilate* (Philips), *Parvamussium donaiense* (Mansuy), *Entolium* sp. aff. *E. partitum* (Sowerby), *Myophorella saurini* Hayami, *Pholadomya fontainei* Hayami and *Thracia loducensis* Hayami occur also in the Toarcian of the Tak Province, northwestern Thailand. It is noteworthy that Hayami (1972) erected *Modiolus sestiniae* Hayami for a species also found in Persia, which suggests a northern Tethyan link.

5.2. Myanmar

Among 68 bivalve species, *Astarte* sp. cf. *A. imbriata* Walton, described by Healey (1908) from the Rhaetian - Lower Liassic Napeng beds in the northern Shan States, is the only species found in common with Thailand. From the two horizons of the Namyau series, Northern Shan States, 63 bivalves species identified largely differ from those found in Thailand, probably due to age difference (Bathonian, Callovian or Lower Oxfordian) (Reed, 1931, 1936).

5.3. Japan

Out of 85 Liassic bivalve species, 20 species are Toarcian, among which 13 species show some affinity with Thailand (Hayami, 1957a-e; 1958a-e; 1959).

5.4. Cutch (India)

Abundant bivalve species were described by Kitchin (1903), Cox (1937, 1940, 1941 1952a-b). The geological age of the Cutch sequence ranges from Middle to Late Jurassic. Eleven species from Thailand show some affinities to the Cutch fauna, including *Lima wynnei* Cox, *Lima callovica* Cossmann and *Bositra ornata* (Quenstedt). However, one has to consider the cosmopolitan nature of these long ranging forms. It confers a low paleobiogeographic evidence with respect to the relationship between the northern Tethyan shallow subtropical environment of SE Asia and the high latitude cold environment of the Indian mass, which is still solidly attached to Gondwana in Jurassic times. It should be noted that the affinities between Western Europe and Cutch (India) were highest during the Callovian, when the northern opening of the Atlantic Ocean brought cold waters into Western Europe (Hirsch, 1980).

5.5. Levant (Sinai and Israel)

Bivalves of this area show similarities with some forms from Western Europe, North and East Africa. Though it shares the subtropical–tropical climatic conditions with

Table 1. Occurrence of marine Jurassic bivalves from the Mae Sot-Umphang area in Thailand and its neighboring countries. ○: same species.

Localities	Thai(Umphang)				Thai(MaeSot)		Vietnam	Myanmar	Iran	Japan	Eope	Levant	Cutch
Species	1	2	KT1	KT6	1	2							
Parallelodon infraliassicus Hayami						aff				○			
Grammatodon jurianus Cox	aff												○
Arcomytilus laitmairensis (de Loriol)		aff								cf	○	○	○
Mytilus heranius Hayami					aff					○			
Inoperna plicata (Sowerby)		aff				aff				○	○		○
Modiolus inbricatus J. Sowrby	aff											○	○
Modiolus sestiniae Hayami					○	○	○		○				
Kobayashites hemicylindricus Hayami	aff									○			
Limawynnei Cox					cf								○
Limacallovica Cossmann					cf			cf			○		○
Plagiostoma tenuistriata Münster		aff									○		
Ostreomya dilata (Phillips)				cf			cf				○		
Somapecten kamimaensis Kimura		aff								○			
Camptonectes fromageti Hayami	aff						Åõ						
Entolium lunare Roemer		aff			aff					cf			○
Entolium partitum (Sowrby)				aff			aff				○		
Parvamussium donaiense (Mansuy)	○	○	○			○	○						
Oxytoma sp.		ap				sp							
Myophorella saurini Hayami	○	○				○	○						
Trigonia (Trigonia) tumida Kitchin		aff				aff							○
Trigonia elongata J. de C. Sowerby				aff									○
Geratrigonia kurumensis Kobayashi			aff							○			
Protocardia contusa Healey						aff		○					
Integricardium hayamii(Keen and Kasey)	aff		aff	aff		aff				○			
Lucina hasei Hayami		aff				aff				○			
Bositra ornata (Quenstedt)								cf		cf	○		○
Astarte fimbriata Walton	cf		cf	cf		cf		cf			○		
Astarte deltoidea Moberg	aff		aff		aff						○		
Eomiodon chumphonensis Hayami						○							
Eomiodon namtuensis Reed				aff				○					
Opis tanourensis Tamura						aff				○			
Pholadomya (Bucardiomya) fontainei	○	○				○	○						
Homomya satoi Hayami	aff									○			
Thracia loducensis Hayami		○	○			○	○						
Thracia prisca Healey		aff				aff		○					

southeastern SE Asia, only two cosmopolitan species show affinity between the Levant and Thailand (Hirsch, 1980).

6. CONCLUSION

The Jurassic bivalves of the Mae Sot and Umphang areas in northwest Thailand shed some light on the possible correlation of Jurassic faunas in Southeast Asia. The identified Toarcian to Aalenian bivalves of Thailand and Vietnam reveal a high degree of endemism and only one, *Modiolus sestiniae* Hayami, is common with Iran, suggesting a northern Tethyan affinity. Among those taxa that show affinity with Cutch and the Levant figure cosmopolite species. The fauna identified here seems thus to characterize a widely endemic SE Asian Province at the edge of Eastern Tethyan Eurasia.

These findings corroborate a Late Triassic–Lowermost Jurassic consolidation of the Shan Thai and Indochina terranes (Hirsch et al., 2006; Ishida et al., 2006). The amalgamation of various allochtonous terranes of Gondwanian origin with several Paleozoic Paleo-Tethyan imprints generated a new landmass at the edge of the Eurasian supercontinent. The Toarcian–Early Bajocian marine transgressions on this new land was thus characterized by widely low latitude endemic faunas with certain northern Neo-Tethyan affinities.

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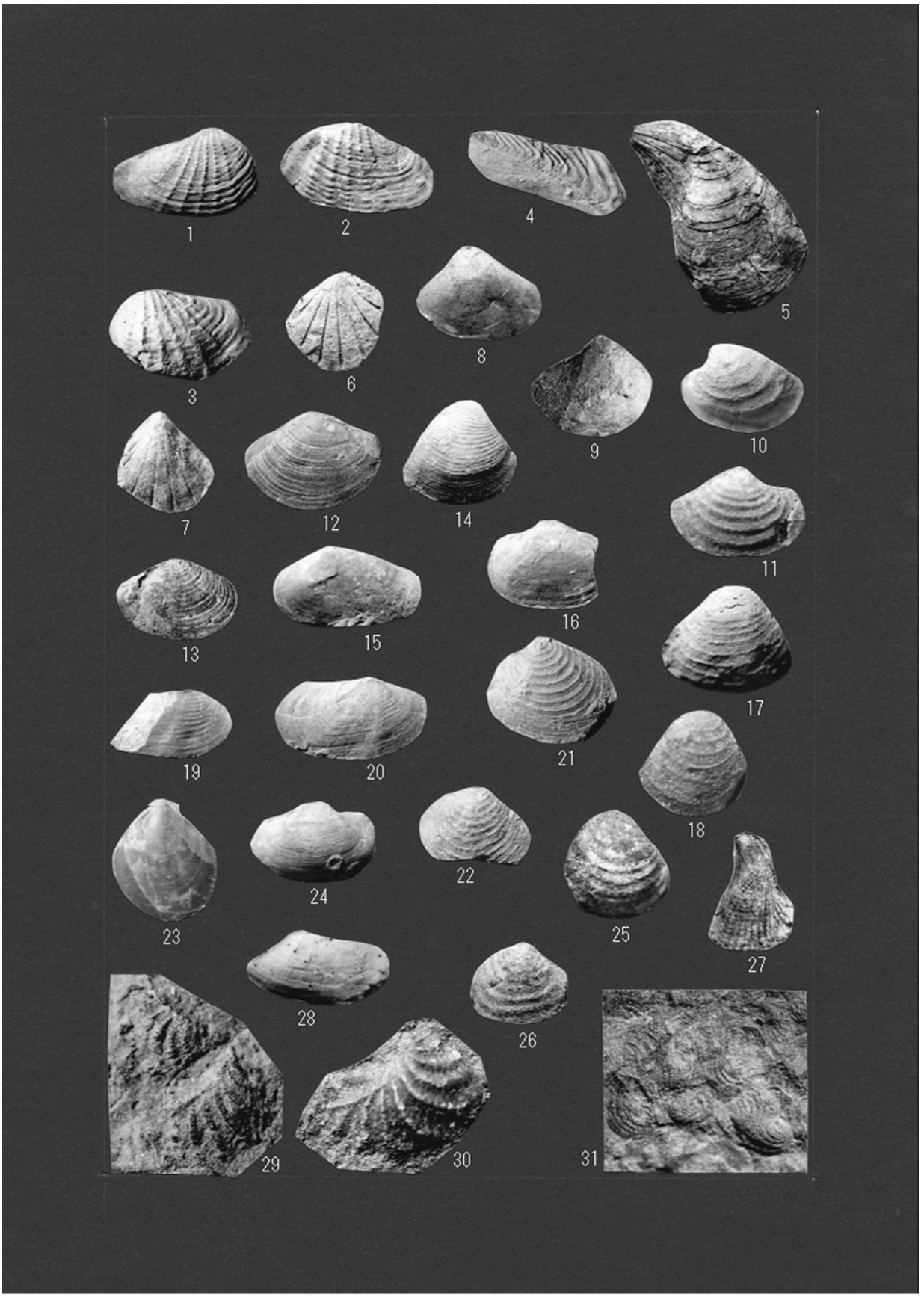
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Plate 1. Figs. 1-3, *Pholadomya fontainei* Hayami. 1: NU-TL-0002, from level 2 (Khun Huai Fm), ×1.7, right valve, 2: NU-TL-0003, from level 2 (Khun Huai Fm), ×1.7, left valve, 3: NU-TL-0005, from level 2 (Khun Huai Fm), ×1, left valve. Fig. 4, *Inoperna* sp. aff. *I. plicata* (Sowerby), NU-TL-0001, from loc. 2 (Klo Tho Fm), ×1.5, left valve. Fig. 5, *Modiolus sestiniae* Hayami, NU-TL-0046, from level 1 (Khun Huai Fm), ×1, left valve. Figs. 6-7, *Parvamussium donaiense* (Mansuy). 6: NU-TL-0013, from loc. 2 (Klo Tho Fm), ×1, right internal mold, 7: NU-TL-0044, from loc. 2 (Klo Tho Fm), ×1, left internal mold. Figs. 8-9, *Protocardia* sp. aff. *P. contusa* Healey. 8: NU-TL-0031, from level 2 (Khun Huai Fm), ×1.5, left valve, 9: NU-TL-0047, from level 2 (Khun Huai Fm), ×1.5, right valve. Figs. 10-11, *Astarte* sp. aff. *A. fimbriata* Walton. 10: NU-TL-0023, from from loc. KT-1 (Klo Tho Fm), ×2.5, left valve. Figs. 12-13, *Thracia loducensis* Hayami. 12: NU-TL-0019, from loc. 2 (Klo Tho Fm), ×2, left valve, 13: NU-TL-0020, from loc. 2 (Klo Tho Fm), ×2, right valve. Fig. 14, *Eomiodon* sp. aff. *E. namtuensis* Reed, NU-TL-0028, from loc. KT-6 (Klo Tho Fm), ×1.5, right valve. Figs. 15-16, *Thracia* sp. aff. *T. prisca* Healey. 15: NU-TL-0041, from level 2 (Khun Huai Fm), ×1, left valve, 16: NU-TL-0040 from level 2 (Khun Huai Fm), ×1, left valve. Figs. 17-18, *Eomiodon chumphonensis* Hayami. 17: NU-TL-0037,from loc. 1 (Klo Tho Fm), ×1.5, left valve, 18: NU-TL-0032 from level 2 (Khun Huai Fm), ×4, left valve. Figs. 19-20, *Ostreomya* sp. cf. *O. dilata* (Phillips). 19: NU-TL-0010 from level 2 (Khun Huai Fm), ×1.2, right valve, 20: NU-TL-0011 from level 2 (Khun Huai Fm), ×1, right valve. Figs. 21-22, *Lucina* sp. aff. *L. hasei* Hayami. 21: NU-TL-0030 from level 2 (Khun Huai Fm), ×1.7, left valve, 22: NU-TL-0048 from level 2 (Khun Huai Fm), ×1.5, right valve. Figs. 23, *Entolium* sp. aff. *E. partitum* (Sowerby), NU-TL-0035, from loc. KT-6 (Klo Tho Fm), ×1, left valve. Fig. 24, *Grammatodon jurianus* Cox, NU-TL-0014, from loc.1 (Klo Tho Fm), ×1.5, left valve. Figs. 25-26, *Astarte* sp. aff. *A. deltoidea* Moberg. 25: NU-TL-0036, from loc. KT-1 (Klo Tho Fm), ×4, right valve, 26: NU-TL-0049, from loc. KT-1 (Klo Tho Fm), ×4, right valve. Fig. 27, *Arcomytilus* sp. aff. *A. laitmailensis* (de Loriol), NU-TL-0018, from loc.2 (Klo Tho Fm), ×4, left valve. Fig. 28, *Parallelodon* sp. aff. *P. infraliassicus* Hayami. NU-TL-0033 from level 2 (Khun Huai Fm), ×1.7, left valve. Figs. 29-30, *Myophorella saurini* Hayami. 29: NU-TL-0043, from loc. 2 (Klo Tho Fm), ×0.7, right valve, 30: NU-TL-0039 from level 1 (Khun Huai Fm), ×2, right and left valves. Fig. 31, *Bositra* sp. cf. *B. ornata* (Quenstedt), NU-TL-0008 from level 1 (Khun Huai Fm), ×2, left and right valves.

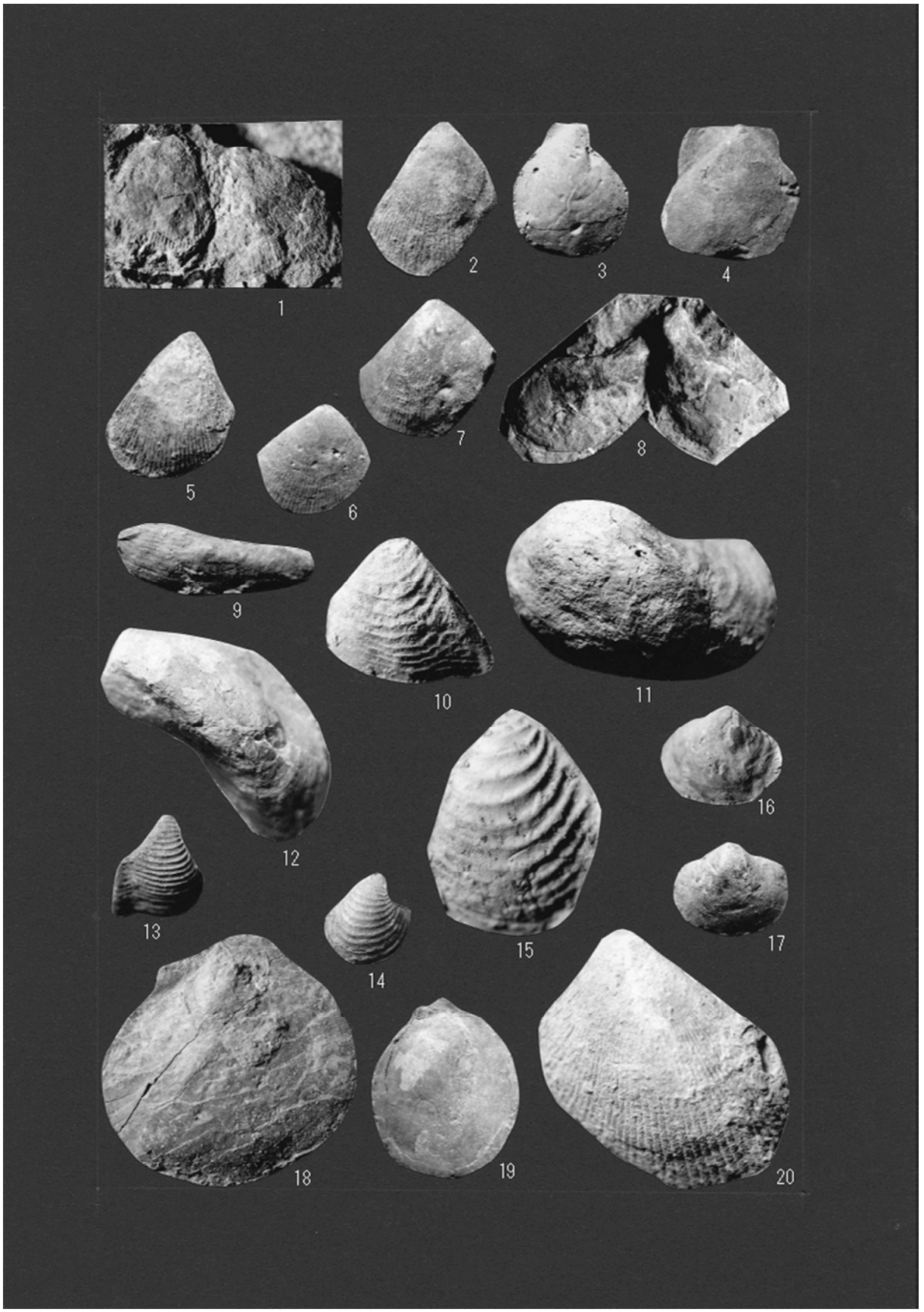
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Plate 2. Figs. 1-2, *Plagiostoma* sp. aff. *P. oepybolus* (Whidborne). 1: NU-TL-0025 from level 1 (Khun Huai Fm), ×1.2, left valve. Fig. 2, NU-TL-0026 from level 1 (Khun Huai Fm), ×1.5, left valve. Fig. 3, *Somapecten* sp. aff. *S. kamimaensis* Kimura, NU-TL-0021, from loc.2 (Klo Tho Fm), ×2, right valve. Fig. 4, *Camptonectes* sp. aff. *C. fromageti* Hayami. NU-TL-0012, from loc.1 (Klo Tho Fm), ×2, right valve. Fig. 5, *Lima* sp. cf. *L. callovica* Cossmann, NU-TL-0038 from level 1 (Khun Huai Fm), ×1, left valve. Figs. 6-7, *Plagiostoma* sp. aff. *P. tenuistriata* Münster. 6: NU-TL-0050, from loc.2 (Klo Tho Fm), ×1.2, right valve, 7: NU-TL-0045, from loc.2 (Klo Tho Fm), ×1.5, left valve. Fig. 8, *Mytilus* sp. aff. *M. heranius* Hayami, NU-TL-0006 from level 1 (Khun Huai Fm), ×1, left and right valves. Fig. 9, *Kobayashites* sp. aff. *K. hemicylindricus* Hayami, NU-TL-0017, from loc.1 (Klo Tho Fm), ×1.2, left valve. Fig. 10, *Trigonia* sp. aff. *T. elongata* J. de C. Sowerby, NU-TL-0024, from loc.KT-6 (Klo Tho Fm), ×1, left valve. Fig. 11, *Homomya* sp. aff. *H. satoi* Hayami, NU-TL-0016, from loc.1 (Klo Tho Fm), ×1, left valve. Fig. 12, *Modiolus inbricatus* J. Sowerby, NU-TL-0015, from loc.2 (Klo Tho Fm), ×1, right valve. Fig. 13, *Trigonia* sp. aff. *T. tumida* Kitchin, NU-TL-0004 from level 2 (Khun Huai Fm), ×2, right valve. Fig. 14, *Opis* sp. aff. *O. tanourensis* Tasmura, NU-TL-0029 from level 2 (Khun Huai Fm), ×2, right valve. Fig. 15, *Geratrigonia* sp. aff. *G. kurumensis* Kobayashi, NU-TL-0022, from loc.KT-1 (Klo Tho Fm), ×1, gum cast of external mold of left valve. Figs. 16:-17, *Integricardium* sp. aff. *I. hayamii* (Keen and Kasey). 16: NU-TL-00426, from loc.1 (Klo Tho Fm), ×0.5, right valve, 17: NU-TL-0034, from loc.1 (Klo Tho Fm), ×0.5, right valve. Figs. 18-19, *Entolium* sp. aff. *E. lunare* Roemer. 18: NU-TL-0009 from level 1 (Khun Huai Fm), ×1, left valve, 19: NU-TL-0027 from level 1 (Khun Huai Fm), ×0.8, right valve. Fig. 20, *Lima* sp. cf. *L. wynnei* Cox, NU-TL-0007 from level 1 (Khun Huai Fm), ×1, left valve.