Horseshoe crabs in Australia

Tomio Itow[1], Hideaki Kato[1] and Kazumi Kato[2]
1) Department of Biology, Faculty of Education, Shizuoka University
2) Department of English, Graduate courses, Shizuoka University

When you watch the title of "Horseshoe crabs in Australia", you may think that there are horseshoe crabs in Australia now. However, there are not any horseshoe crabs in the Australia zone including the Australian Continent now. This report concerns horsesoe crabs which used to live in Australia and were found as fossils.

On the other hand, three species of horseshoe crabs now live in east south Asia, that is, the Oriental zone. The boundary of the Oriental zone and the Australia zone is the Wallace's line or the Weber's line. The Wallace's line situates at the west of the Sulawasi (Celebes) island, and the Weber's line situates at the east of the same island. There is a report that a species of horseshoe crab, ***Tachypleus tridentatus*** lives in the Sulawasi island (Sekiguchi,1988). Therefore in future, we may find some living horseshoe crabs under the natural conditions at north west Australia.

There are now four species of horseshoe crabs in the world. ***Limulus polyphemus*** lives in the east coast on Northern American Continent. Other three species live on Asian Continent. ***Tachypleus tridentatus*** lives in Japan, south China, north Vietnam and islands of east south Asia. ***T. gigas*** lives the area of Asian Continent from south Vietnam to east India and the islands of South-East Asia. ***Carcinoscorpius rotundicauda*** lives in the area of Asian Continent from south China to east India and the islands of South -East Asia. We can notice those three Asian species live in the Oriental zone except Japan.

The ancester of all four species is seemed to be the same species called ***Mesolimulus walchi*** which inhabited in Europe 200 million years ago.

There are only four species of horseshoe crabs in the present world, but there used to be many species of horseshoe crabs in the whole world. In Australia, there were many horseshoe crabs. Almost of those horseshoe crabs in Australia lived in fresh water. We are surprised in this fact, because all present horseshoe crabs live in sea water or brackish water.

We visited Australia in 2001 and could get the informations about fossils of horseshoe crabs there. We now report you about the rise and fall of Australian horseshoe crabs (Fig. 1).

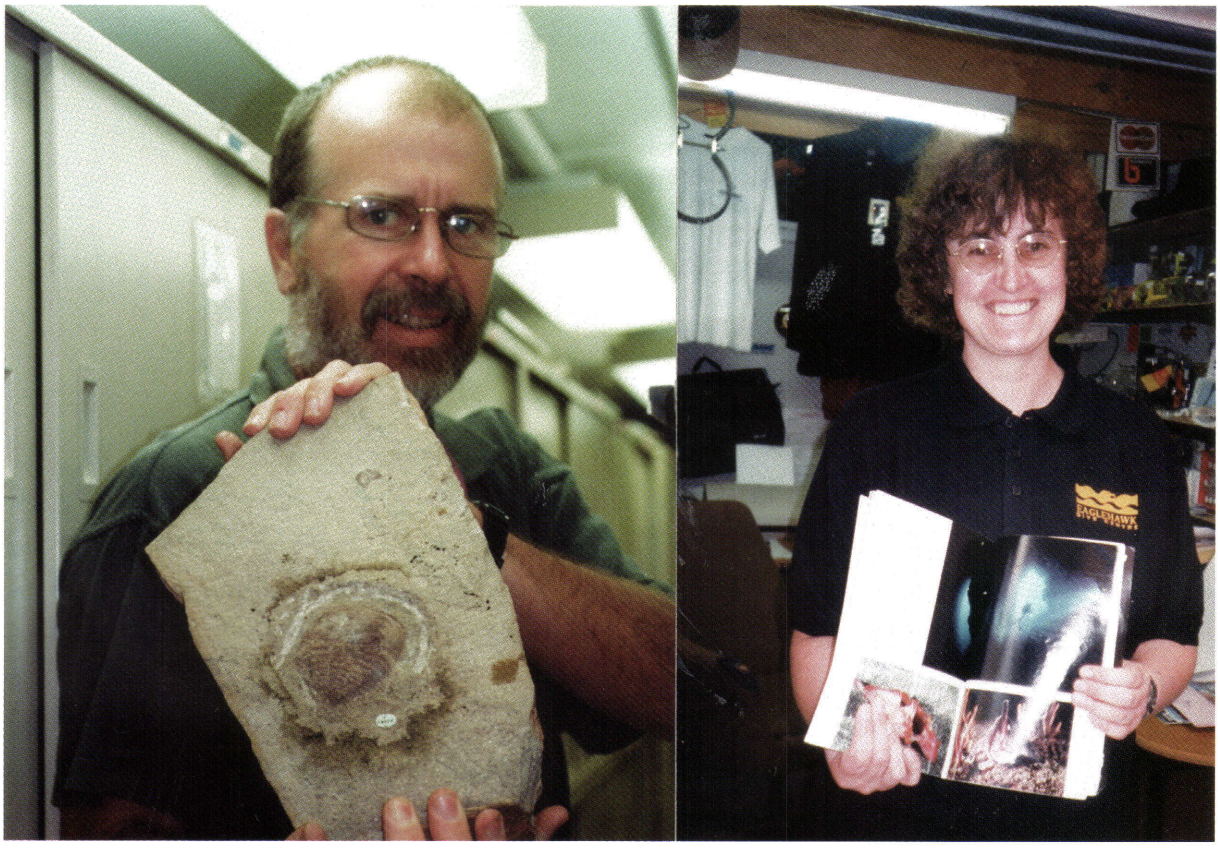

Fig. 1. Dr. Robert Jones of Australian museum (left)and Dr. Karen Gowlett-Holms of Eagle Howk Diver Center, Tasmania.

More than 200 milion years ago, all continents were gathered into only one land in the earth. Australia was face to the south pole Continent and India and close to Africa Continent. At the time, Australia was situated at the higher latitude than present one. We call the gathered land Pangaea. As there is a Ocean called Tethys Sea, Pangaea was divided into two parts. We call the north part Laurasia Continent or Angara Continent, and the south part Gondwana Continent.

Mesolimulus walchi used to inhabit in the Europe which was in Laurasia Continent, therefore we can regard they inhabit on the north coast of Tethys sea. The horseshoe crabs, which moved toward west, became ***Limulus polyphemus*** and another horseshoe crabs, migrated toward east, became Asian horseshoe crabs. We can suppose to think the horseshoe crabs came into India after when the Indian subcontinent hit the Laurasia and became one land the Eurasian Continent (Fig. 2).

At 600 million ago, the beginning of the Paleozoic era (Table 1), the very strong living organism appeared and prospered. That is trilobites (【Subphylum】 Trilobitomorpha). The trilobites became extinct at the end of the Paleozoic era, 230 million ago. On the other hand, its direct descendant【Subphylum】Chelicerata including horseshoe crabs still have survived until the present, somehow. Horseshoe crabs seem to have been evolved from 【Order】 Redlichiida in trilobites at the first period of the

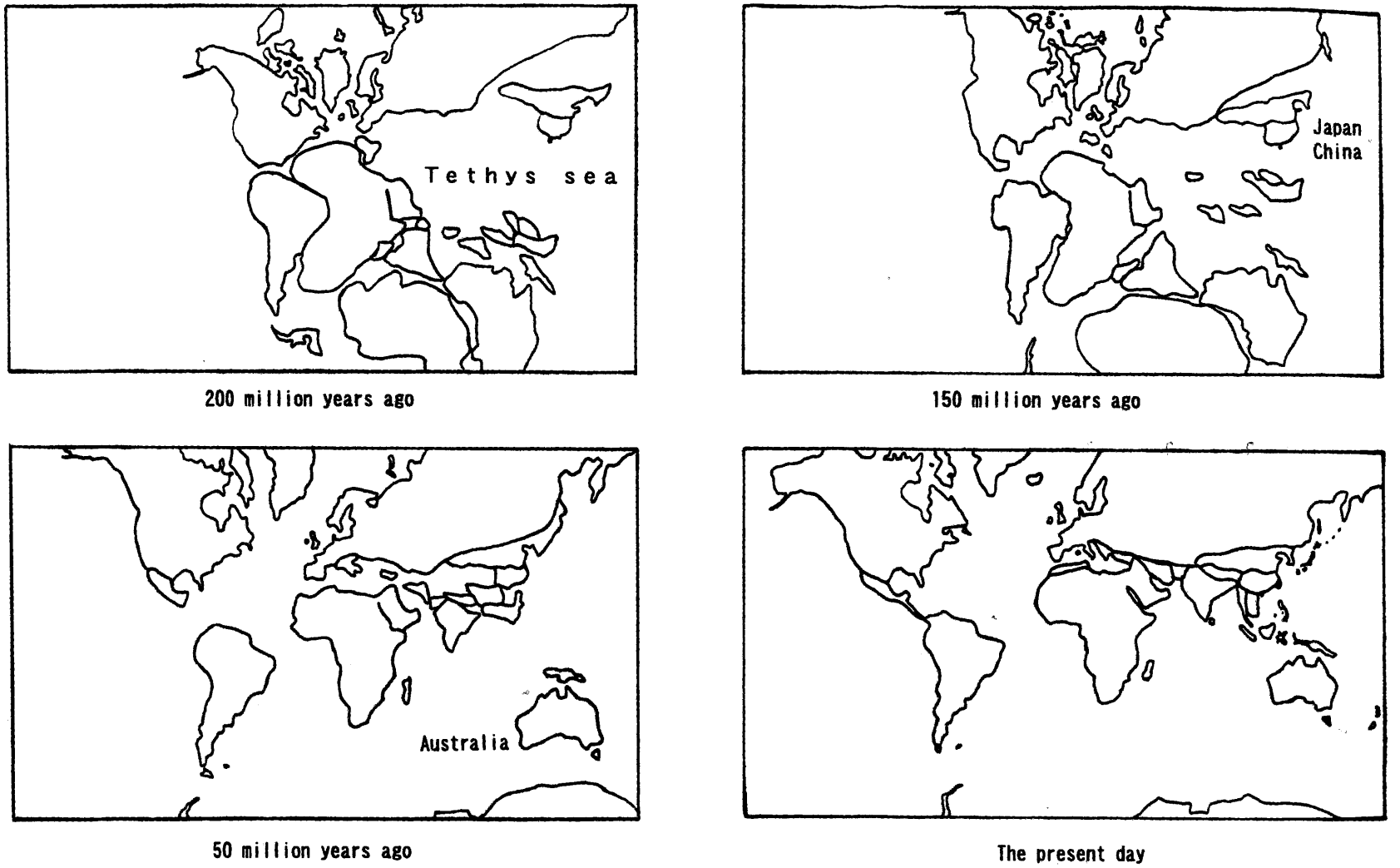

Fig. 2. The separation and migration of continents.

Eras	Periods	Millions of years ago
Cenozoic	Quaternary	2
	Tertiary	70
Mesozoic	Cretaceous	135
	Jurassic	180
	Triassic	230
Paleozoic	Permian	270
	Carboniferous	350
	Devonian	400
	Silurian	430
	Ordovician	490
	Cambrian	600
Precambrian		4600

Table 1 Table of geologic time

Paleozoic era. Somebody say horseshoe crabs evolved from 【Suborder】 Redichia of 【Order】 Redlichiida in trirobites, but we can see more similarity with ***Olenellus vermontanus*** of 【Suborder】 Olenellia in same 【Order】 Redlichiida (Fig. 3).

The famous sea scorpions (【Class】 Eurypteria) are also relative with horseshoe crabs. Both animals belong to 【Subphylum】 Chelicerata. One kind of sea scorpions reached the land and was evolved into land scorpions and spiders, that is, 【Class】 Arachnida.

Both trilobites and sea scorpions inhabited widely but they became exinct in the Paleozoic era. Only the horseshoe crabs have still alive in the present sea among Trilobitomorpha and marine Chelicerata. Consequently, we should protect horseshoe crabs.

Fig. 3.
The trilobite look like horseshoe crabs, ***Olenellus vermontanus.***
From Dr. Chip Clark of Smithonian museum, Washington D.C.

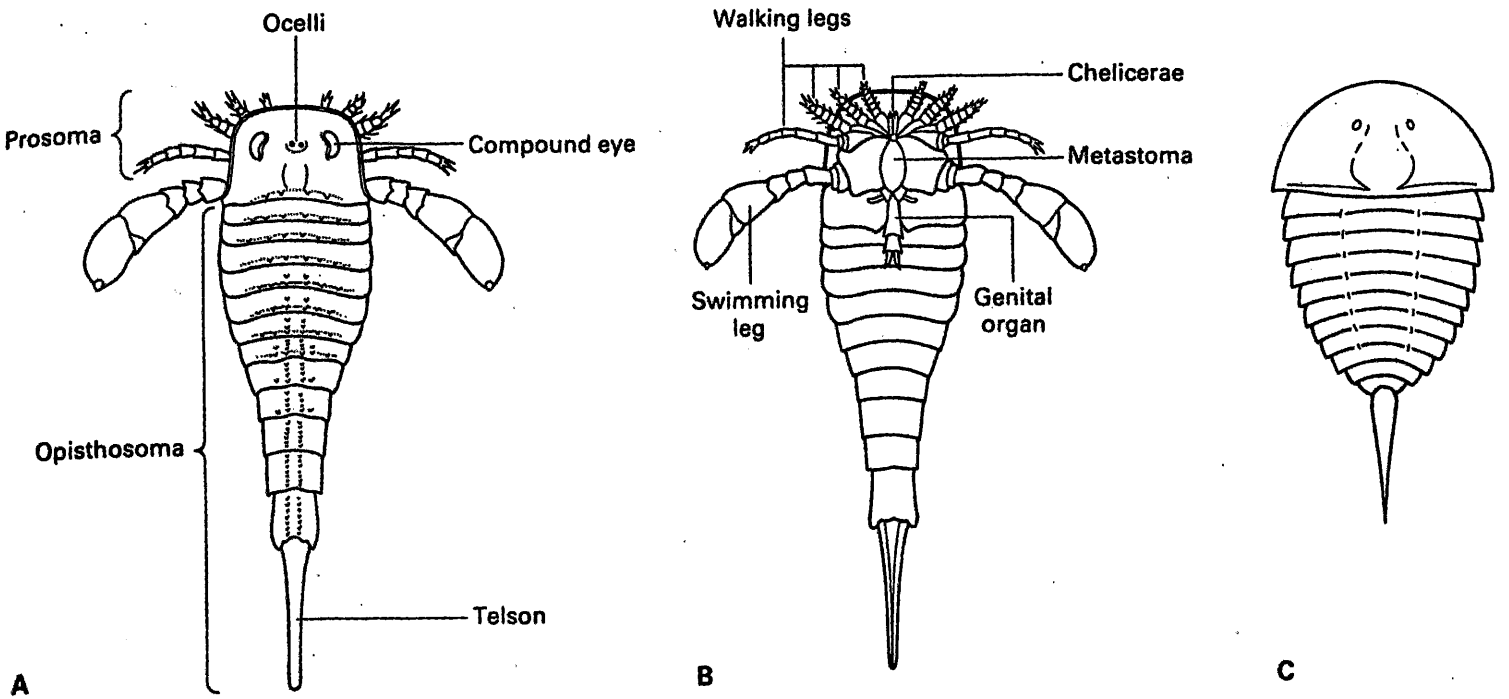

Fig. 4. Eurypterid (A & B) and Aglaspis (C). From Bcardman (1987).

[PHYLUM]	ARTHROPODA
[Subphylum (I)]	Trilobitomorpha [trilobites]
[Subphylum (II)]	Chelicerata
[Class (1)]	Xiphosura
[Order ①]	Aglaspida
[Order ②]	Xiphosurida [horseshoe crabs]
[Suborder (i)]	Synziphosurina
[Suborder (ii)]	Limulina
[Family (1)]	Paleolimulidae
[Family (2)]	Mesolimulidae
[Family (3)]	Limulidae
[Class (2)]	Eurypteria [sea scorpions]
[Class (3)]	Arachnida [scorpions, spiders & so on]

Table 2 A taxonomy of horseshoe crabs and related animals. Somebody call the group of Xiphosura and Eurypteria as Merostomata.

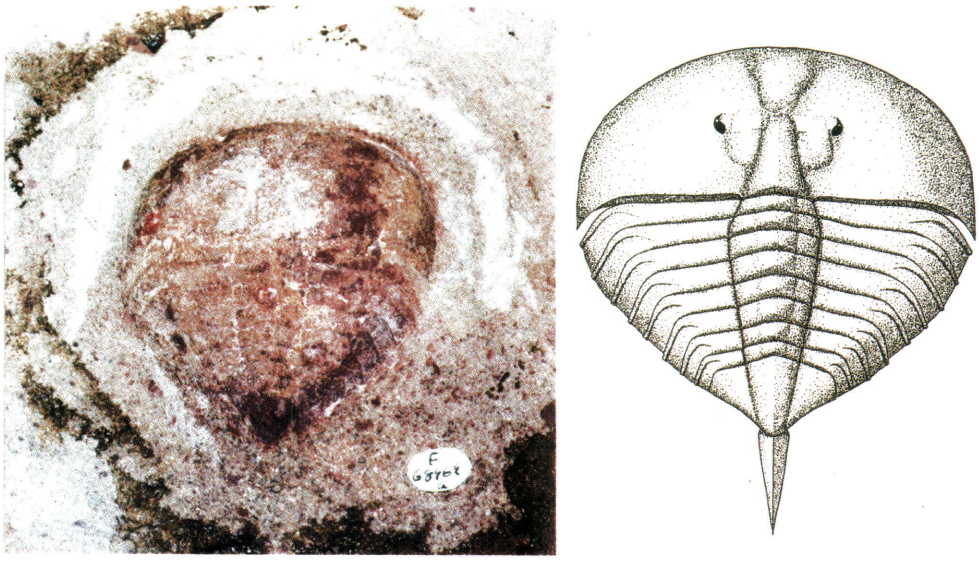

Fig. 5. ***Kasibelinurus amicorum***. The figure was written by Pickett (1993), and the photograph was taken by us at Australian museum.

The process of evolution such as the evolvement from 【Subphylum】 Trilobitomorpha to 【Subphylum】 Chelicerata, the appearance of 【Class】 Xiphosura and the appearance of 【Order】 Xiphosurida seem to occur in Laurasia Continent according to fossil unearthing. When we call horseshoe crabs in paleontology, it stands for the species of 【Order】 Xiphosurida. So that 【Order】 Aglaspida in same 【Class】 Xiphosura is not called horseshoe crabs (Table 2 and Fig. 4).

Most fossils of horseshoe crabs and its relatives are definitely found in Laurasia Continent and very a few of those fossils are found in Gondwana Continent including Australia. Only five kinds of fossil horseshoe crabs have been reported in Australia. However, it is certain that horseshoe crabs used to inhabit in Australia.

The oldest fossil horseshoe crabs in Australia are ***Kasibelinurus amicorum,*** founded

in the stratum of late Devonian period, 400 million to 350 million years old. The word ***Kasibelinurus*** means a company of ***Belinulus***. ***Belinulus*** is the horseshoe crab founded in Europe and it means tails such as the arrow. The word amicorum means "friendly". The lengt of ***Kasibelinurus amicorum*** fossile is 63mm and it was founded at near the Parkes in New South Wales (Fig. 5; Pickett 1993). As it was founded at the sea layers, it is likely to be saltwater horseshoe crabs. To ours interests, other horseshoe crabs in Australia were found in the fresh water strata. There are reports of the fossil horseshoe crabs as the same genus as ***Kasibelinurus*** species in Europe and North America Continents so that the genus widely spread in the earth.

Kasibelinurus belongs to 【Suborder】 Limulina. There are various opinions in relation with 【Family】 to which it belongs. We feel it can belong to 【Family】 Paleolimulidae, but Pickett (1933) made it belongs to the new 【Family】 Kasibelinurus. We can not agree to make many 【Family】. It is very difficult. We think the horseshoe crabs of the Paleozoic era are classified into 【Family】 Paleolimulidae except the species belonging to 【Suborder】 Synziphosurina, and ones of the Mesozoic era into 【Family】 Mesolimulidae, and ones of the Cenozoic era including the present ones into 【Family】 Limulidae.
That is, there are only three families.

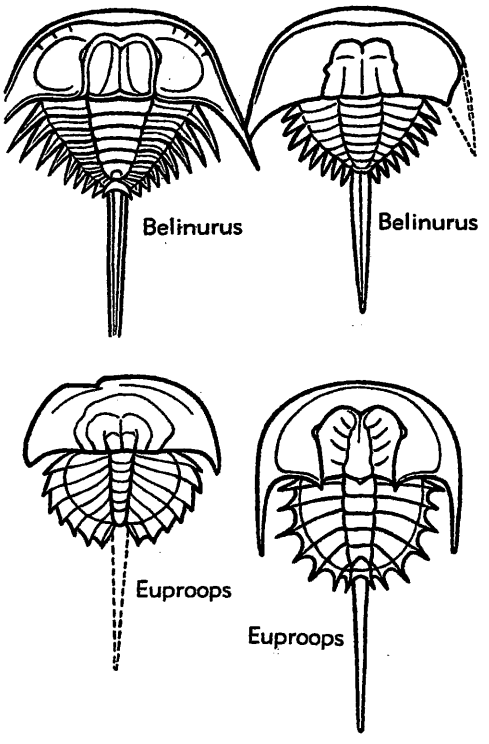

Fig. 6.Belinurus and Euproops. From Moore (1977).

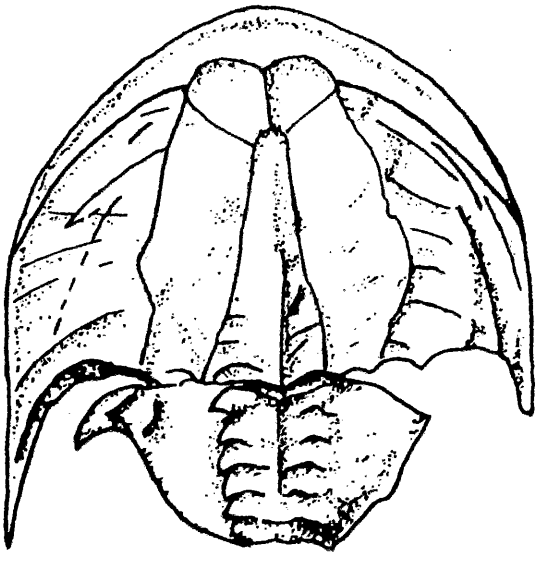

Fig.7. The horseshoe crab fossil of Paleolimulidae from Tasmania. From Ewington & Banks (1989).

There is a same problem about 【Superfamily】. We think 【Superfamily】 is not needed. Somebody think 【Superfamily】 Belinuracea and 【Superfamily】 Euproopacea. However, we can not feel that there is big differences between Belinuracea, Euproopacea (Fig. 6) and Paleolimulidae, so that it is unnecessary for them to divide many 【Superfamily】. We propose Belinurus and Euproops should belong to 【Family】 Paleolimulidae in 【Suborder】 Limulina.

We can see the body segments of 【Suborder】 Synziphosurina have been independent and each segments work individually. On the other hand, the segments of 【Suborder】 Limulina fuse. The segments of 【Family】 Paleolimulidae is clear in spite of fuse.

Fig.8. ***Dubbolimulus peetae.***
The figure was written by Pickett (1984), and the photograph was taken by us at Australian museum.

The fossil of Synziphosurina, similar to ***Kasibelinurus,*** has been found from the strata of early stage of Devonian period in Bolivia of south America (Eldredge, 1974). This Bolivian fossil has been recorded as the oldest horseshoe crab in Gondowana Continent. The theory of that the evolutionary process from 【Suborder】 Synziphosurina to 【Suborder】 Limulina happened in Laurasia Continent, is strong possibility but we can not deny that the process might have happened in Gondowana Continent.

An Aglaspida fossil has been found from the strata of the late Cambrian period in the early Paleozoic era at north Tasmania, Australia (Jago and Baillie, 1992). Aglaspida is not horseshoe crabs, but it is close order of Xiphosurida, that is, horseshoe crabs (Table 2 and Fig. 4).

A fossil, ***Hemiaspis tunnecliffei*** has been found from the strata of Silurian period and another fossil, ***Pincombella belomontensis*** has been found from the strata of late Permian period. Both species were reported as horseshoe crabs by Chapman (1932). However, as the result of detailed investigation, it elucidated that ***Hemiaspis tunnecliffei*** was a species of trilobites and ***Pincombella belomontensis*** was an insect (Pickett, 1984). The fossil, certainly judged as a horseshoe crab, is a Paleolimulidae which has been found from the strata of the late Permian period in Poatina in Tasmania island

Fig. 9. ***Austrolimulus fletcheri***. The photograph was gotten at Australian museum.

Fig. 10. ***Victalimulus mcqueeni***. From Riek & Gill (1971).

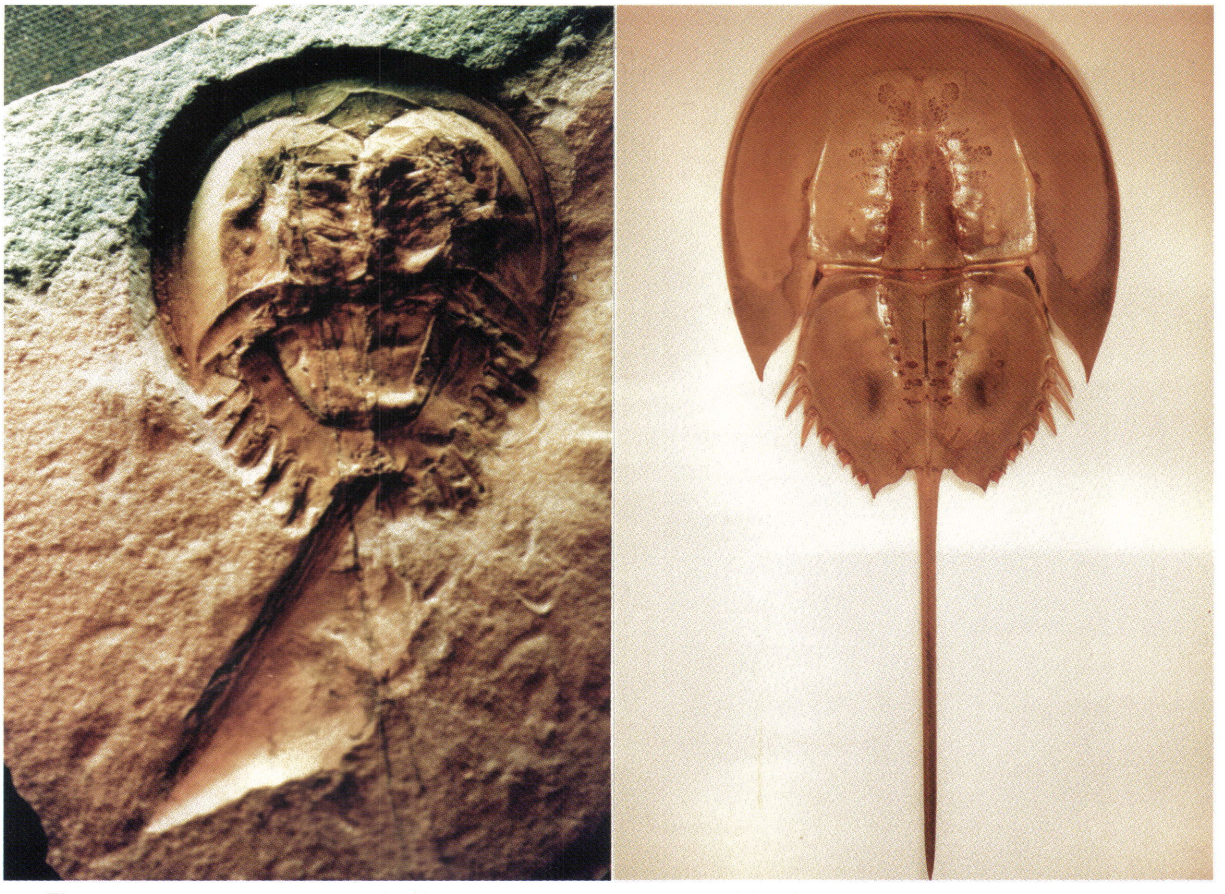

Fig. 11. ***Mesolimulus walchi*** (left) and ***Limulus polyphemus*** (right).
The photograph of *Mesolimulus* was taken at Solnhofen museum in Bayern, Germany.

(Fig. 7, Ewington etal., 1989). It located between 75 to 80 degrees south latitude and suppose to be cold climate at the time. And the fossils has been found from the strata, made from fresh water, so that the horseshoe crabs are supposed to be fresh water horseshoe crabs. The length is 3 cm, except for tail telson.

Horseshoe crabs, born in Paleozoic era, lived over the last Paleozoic era which trilobites came exinct and also horseshoe crabs inhabit during the period of dinosaurs, Mesozoic era. Horseshoe crabs in Australia also lived over the time of extinct at the end of Paleozoic era.

The fossil of ***Dubbolimulus peetae*** has been found from the strata of the middleTriassic period of Mesozoic era at Dubbo in New South Wales (Fig, 8, Pickett, 1984). As it is a horseshoe crab in Mesozoic era, we can classify it into the 【Family】 Mesolimulidae, but Pickett (1984) proposed it belongs to new 【Family】 Dubbolimulidae. Surely we can see the wide prosoma which is peculiar to Australian horseshoe crabs, on the ***Dubbolimulus. Dubbolimulus*** is said to live in flesh water. The total length is 4 cm, width of prosoma is 27.8 mm, and the length of prosoma is 14.0 mm.

An astonishing, symbolic Australian fossil horseshoe crab was found from the 200 million years old strata of Beacon hill at Brookvale of Sydney in New South Wales. It is ***Austrolimulus fletcheri*** (Fig. 9, Rick, 1955, 1968). It may belong to 【Family】

Mesolimulidae, but Rick (1955, 1968) has proposed new 【Family】 Austrolimulus. Two fossils have been found and the bigger one's total length is 14.6 cm, the length excluding telson is 5.7 cm. The width is 17.8 cm. You can recognize the widthis longer than the length. There is no stings on the abdomens and telson is longer than the body. This symbolic Australian horseshoe crab is also supposed to be in fresh water.

The last horseshoe crab in Australia has found from the strata of early Cretacean period at Koonwarra in Victoria. It is ***Victalimulus mcqueeni*** (Fig. 10, Rick and Gill, 1971). This horseshoe crab is the latest one in Australia. Cretaceous is the last period of Mesozoic era and the wild extinction happened and dinosaurs also became exinct at the time. Although Australian horseshoe crabs lived over the last Paleozoic era, they seemed not to be able to live over the last Mesozoic era and they became extint in the same way as dinosaurs. This ***Victalimulus*** also found from the strata of fresh water so that they seem to have lived in fresh water. However, Rick and Gill (1971) mentioned it might have lived in salt water or brackish water, considering that there are stratas of salt water near there. If the conjecture is true, it is possible to think that they had gone into the river or lake and became a fossil after millions years. This ***Victalimulus*** looks like ***Mesolimulus walchi*** which lived in Europe before 200 millions years and the ancestor of present horseshoe crabs. We think it should be studied more about the origin of ***Victalimulus.***

Mesolimulus walchi found from strata of salt water and the four kinds of living horseshoe crabs are all living in salt water (Fig. 11). But, They prefer weak salt water than strong salt water, nevertheless there is a record of ***Carcinoscorpius rotundicauda*** was found in the river which is 150 km far from the river mouth. ***Limulus polyphemus*** vitaly live in near 50% sea water.

After all, Australian horseshoe crabs are said to extinct wholly at the end of Mesozoic era, but we expect that living horseshoe crabs in fresh water might still exist in some rivers or lakes of Australia, because Australia is the mysterious continent.

Acknowledgement

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