Shell of the recent bivalves living in intertidal zones show various growth patterns which reflect the characters of tides of their habitats (EVANS, 1972; RICHARDSON et al., 1979; OHNO, 1983a, b), and such patterns are found also in fossil bivalve shells (OHNO, 1984). This article reports, that also shells of gastropods show tidal growth patterns taking Monodonta labio (LINNAEUS, 1758) as an example. We express our hearty than as to Dr. Eiji TSUCHIDA of Ocean Research Institute to the University of Tokyo, who kindly gave us specimens from Palau Islands. This study is partly supported by the fund for the senior author as a postdoc fall of the JSPS, 1983.

Examined specimens came from tidal zones of two localities: Near Koror, Palau Islands and Uranouchi Bay, Kochi Prefecture, Japan. Shells were bedded in plastic and cut along the line A-B in Text-fig. 1. They were abraded with carborundum until the grain size of #3000, then polished with diamond paste. The polished samples were etched with 0.1 mol HCl for about 40 seconds. These samples were then coated with Au and observed under a SEM.

Shell of Monodonta labio is composed of aragonite (TOGO, 1977) and consists of three layers (Pl. 1, fig. 3). The outer layer and innermost layer are composed of fine acicular crystals and the inner layer is nacreous. The innermost layer is confined to the region near the margin of the apperture, and is lacking in some specimens. There are two components of incremental growth (Pl. 1, fig. 2): thinner growth lines (L) and thicker growth increments (I) between growth lines. Growth lines are observed in all of the three layers mentioned above, but most clearly in the outer layer and in the innermost layer.

In the shells of specimens from the Palau Islands, there is an alternation of thicker and thinner growth lines both in outer and innermost layers (Pl. 1, figs. 2, 4). The order of the appearance of thicker and thinner growth lines changes also periodically. Therefore, in an arbitrarily numbering, if growth lines with odd numbers are thicker at first, then after an interval, growth lines with even numbers become thicker. In the samples from Uranouchi Bay (Pl. 1, fig. 1), there are parts (S) with thicker and thinner growth lines alternating in a similar manner as observed in the specimens from Palau Islands, which are separated from each other by parts with widely spaced growth lines (N).

The growth pattern of Monodonta labio of Palau Islands is quite similar as that seen in the bivalve shells living in about middle tide line of intertidal zones in regions of semidiurnal tides.
In bivalve shells of such level, growth lines are formed at each low tide, when they are emerged. Because of the difference of activity of bivalves, growth lines formed at daytime low tides are thicker than those at night time low tides. This causes, besides an alternation of thicker and thinner growth lines, the change of the order of thicker and thinner growth lines with a period of 14.77 days. Therefore the growth pattern is in this case a result of interference of 12.4 hours period of low tides and day-night change with 24.0 hours period (OHNO, 1983b).

To examine, whether the growth pattern of Monodonta labio from Palau Islands is formed with the same cause as that of bivalves, a sequence of 102 growth lines of a sample of Monodonta labio was observed and each line is classified into three categories; thick, thin, and not assignable. The designations of the lines are plotted in a diagramm with 12.4 hours interval, which corresponds the period of low tides. The ordinate of the diagramm represent days before the collection of the shell, and the abscissa the time of the day. (Because the time of collection is not known for the specimens from Palau Islands, the last low tide was setted arbitrarily at about 18:00 o’clock). On such a diagramm, the distribution of thick or thin growth lines will be confined to a certain time interval of the day, when both of the following two conditions are filled:

1) growth lines are formed with 12.4 hours period,
2) pattern of thicker and thinner growth lines is caused by the interference of 12.4 hours period of tide and day-night change with a period of 24.0 hour.

The plot for the Monodonta specimen is shown in Text-fig. 2. Thick growth lines are confined to the time period between 6 and 18 o’clock and the thinner growth lines to the time period between 18 o’clock and the 6 o’clock. Therefore it is quite probable, that the growth pattern of Monodonta labio from Palau Islands is caused by the interference of 12.4 hours period of low tides and day-night change with 24.0 hours period.

Similar patterns as that of specimens from Uranouchi Bay are common in shells of bivalves living between middle tide line and low tide line. In those bivalve shells parts with alternation of thinner and thicker lines are formed in the same manner as mentioned above. These parts are separated
Text-fig. 2.
A sequence of 102 growth lines of a Monodonta labio specimen from the vicinity of Koror, Palau Islands, plotted with an interval of 12.4 hours: ordinate = days before collection of the shell; abscissa = hours; 1 = thick growth line; 2 = thin growth line; 3 = line, which is not assigned to either category.

Tidal patterns in hard tissues of organisms could be applied in biology, paleontology, and geology, for example, estimation of growth rate with a resolution of 12.4 hours, recognition of intertidal fauna, reconstruction of patterns of paleo-tides, past shore lines, etc. Further efforts should be done to collect more detailed informations about the manner of growth line formations of gastropods, because the existence of tidal patterns in gastropod shells extends the fields of application enormously. They are very abundant not only in the present sea but also throughout the geological time, from the middle of the Cambrian Period, even before the appearance of the bivalves.

References
Explanation of Plate 1

(In all the figures, direction of growth is to the right, scales indicate 0.1 mm.)

Monodonta labio (Linnaeus, 1758)

Fig. 1. A specimen from Uranouchi Bay, Kochi Prefecture, Japan. This specimen shows a well defined tidal pattern in the outer shell layer. S = parts with an alternation of thicker and thinner growth lines. N = parts with widely distributed growth lines.

Figs. 2—4. A specimen from the vicinity of Koror, Palau Islands.

2. Alternation of thicker and thinner growth lines in the innermost layer: L = growth lines; I = a growth increment.
3. Section of the shell, showing three layers: O = outer layer; I = inner layer; IM = innermost layer. Growth lines are clearly visible both in outer and innermost layers.
4. Alternation of thicker and thinner growth lines in the innermost outer layers.
短 報

腹足類 Monodonta labio (LINNAEUS, 1758)
の殻に見られる潮汐成長パターン

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（要 旨）

パラオ島と高知県浦之内湾の潮間帯から得られた Monodonta labio の殻から
腹足類ではじめて、潮汐周期を反映した成長パターンが見い出された。