# The Development of Momi and Tsuga Forest : The Influence of Broad-leaved Trees on the Growth of Two dominant Conifers, Momi and Tsuga Trees

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# The Development of Momi and Tsuga Forest
## The Influence of Broad-leaved Trees on the Growth of Two dominant Conifers, Momi and Tsuga Trees

Tatsuro YURUKI and Kazutoshi ARAGAMI


## Abstract

The influence of broad-leaved trees on the growth of two conifers, Momi and Tsuga trees was explained by the changes of individual ranking, including that of broad-leaved trees, from an early stage in the development of the community.

1) Judging from the age structure, it was considered that Momi and Tsuga trees, and broad-leaved trees on the surveyed plots had developed in gaps or openings in the forest.

2) Momi and Tsuga individuals established earlier in gaps or openings in the forest were superior to broad-leaved trees in competition from an early time in the development of the community and became stable in a superior position.

3) On the other hand, most of the Momi and Tsuga trees established later stagnate in a subordinate position as a result of oppression from the upper trees. This phenomenon indicated that the occurrence period, i. e., the time of establishment, affected the growth of individuals.

4) Momi and Tsuga individuals were ranked in three classes-superior, medium and subordinate in a Momi and Tsuga forest, but when broad-leaved trees outnumbered Momi and Tsuga trees, those of the latter in the medium class were few.

5) Broad-leaved trees co-existing with Momi and Tsuga trees were composed of a large number of middle-sized and small trees, and a small number of large trees. It was considered that the paucity of large broad-leaved trees also promoted the superiority of Momi and Tsuga trees in a natural forest.


## Introduction

In general, Momi ( *Abies firma* S. et Z.) and Tsuga (*Tsuga sieboldii* Carr.) trees form a community co-existing with broad-leaved trees. To date, we have studied the development of Momi and Tsuga forest by the changes of individual ranking in diameter (YURUKI *et al.*, 1987a) (YURUKI *et al.*, 1987b). The influences of broad-leaved trees on the growth of Momi and Tsuga can be summarized as follows : When Momi and Tsuga trees become competitively superior to broad-leaved trees, the ranking of the superior trees is not influenced by the removal of broad-leaved trees, but the ranking of medium and subordinate trees fluctuates actively for a time. This fluctuation becomes weak with the gaps or opening closure by the superior trees. In such a case, it is rare for medium and subordinate trees to outrank the superior trees. However, the influence of broad-leaved trees on Momi and Tsuga trees at an early time in the development of the community has not yet been investigated.

In this paper, we discuss and explain the influence of broad-leaved trees on the growth of Momi and Tsuga trees by the changes of individual ranking, including that of broad-leaved trees, from an early time in the development of the community.

## Materials and Methods

Natural Momi and Tsuga forests were investigated in Compartment 35 of Kyushu University Forest in Miyazaki (latitude: 32°23′ N; longitude: 131°10′ E; altitude: 1100 m; warmth index: 80; topography: middle of south slope; inclination of slope: 10°; geologic bedrock: sand stone・clay slate・shale; soil type: moderately-moist brown forest soil ($B_D$)). Broad-leaved trees and Suzutake (*Pseudosasa purpurascens* Mak.) always co-exist with Momi and Tsuga in the forests.

Four plots (20×20 m) were established in these forests in 1972. For all individual trees (Momi, Tsuga and broad-leaved trees) on the four plots, two diameters crossing at right angles to each other at the cutting height (20 cm above the ground) were measured with an accuracy of 1/10 mm and averaged. The measurement of diameter could date back as far as 90 years before the cutting time. Each individual ranking was determined according to the size of each tree diameter at a certain time, and the fluctuation of rankings in the interval of two successive measurement times was calculated. A plus value was used when a ranking increased for ten years, a minus value when it decreased. The growth of Momi and Tsuga trees on plot 1 has been reported in the previous paper (Yuruki *et al*., 1987b). In the present study, all data including those from plot 1 were analyzed.

## Results and Discussion

Table 1 shows the surveyed trees. The number of trees per plot was much the same (71～81), but the ratio of Momi and Tsuga trees to broad-leaved trees on each plot was different. On plots 1 and 4, broad-leaved trees accounted for more than 50% of the whole. On the other hand, on plots 2 and 3, the ratio was less than 30%. Most of the broad-leaved trees were low and middle-sized trees, except a few high trees such as *Fagus crenata, Prunus jamasakura, Acanthopanax sciadophylloides, Kalopanax pictus* (Thunb), etc.

### 1. Age structure

The tree ages used in this paper indicate the number of annual rings at the cutting height. Accordingly, the number of annual rings plus the number of years taken to reach the cutting height is the true age of the tree. However, as it was difficult to estimate the additional number of years for all trees, the number of rings at the cutting height was used as the tentative age in this study.

Table 1　Tree species appeared in investigated plots

| Species | Number on | | | |
|---|---|---|---|---|
| | Plot 1 | Plot 2 | Plot 3 | Plot 4 |
| *Carpinus laxiflora* (Sieb. et Zucc.) Blume | 5 | | 2 | 2 |
| *Fagus crenata* Blume | | 1 | | |
| *Illicium religiosum* Sieb. et Zucc. | 1 | | | 1 |
| *Prunus jamasakura* Sieb. ex Koidz. | 1 | | | |
| *Pourthiaea villosa* (Thunb.) Decne. var. *laevis* (Thunb.) Stapf | 1 | 2 | | 2 |
| *Acer sieboldiana* Miq. | 1 | | 3 | 1 |
| *Ilex macropoda* Miq. | 2 | 3 | 3 | 6 |
| *Ilex pedunculosa* Miq. | | 2 | | |
| *Ilex crenata* Thunb. | | | | 4 |
| *Acanthopanax sciadophylloides* Fr. et Sav. | 1 | | 2 | |
| *Kalopanax pictus* (Thunb.) Nakai | | | 1 | |
| *Clethra barbinervis* Sieb. et Zucc. | 5 | 3 | | 12 |
| *Pieris japonica* D. Don | 18 | 8 | 7 | 7 |
| *Lyonia neziki* Nakai | 6 | 2 | 3 | 2 |
| *Styrax japonica* Sieb. et Zucc. | 1 | | | 2 |
| *Symplocos coreana* Ohwi | | | 1 | 1 |
| *Fraxinus lanuginosa* Koidz. | 2 | 2 | 1 | 4 |
| *Tsuga sieboldii* Carr. | 25 | 41 | 38 | 24 |
| *Abies firma* Sieb. et Zucc. | 12 | 16 | 15 | 11 |
| Total | 81 | 80 | 76 | 79 |

As shown in Fig. 1, the ranges of tree age showed considerable differences among plots. Plot 3 had the narrowest range (71～112 years) and plot 4 had the widest range (42～118 years). Judging from the age structure, Momi and Tsuga trees, and broad-leaved trees were co-existing with each other from the initial stage of community formation. In comparison with broad-leaved trees, the occurrence of Momi and Tsuga trees was concentrated within a narrow range. From these age structures, it was considered that the Momi and Tsuga trees on the surveyed plots had developed in the gaps or openings in the forest (NAKAO, 1985) (SUZUKI, 1980).

### 2. Height growth

Figure 2 shows the frequency of trees in every height class on each plot. Most of Momi and Tsuga trees formed the overstory (tree height >15 m). On the other hand, most of the broad-leaved trees formed the middle (h. 15～5 m) or understory (h. <5 m).

### 3. Individual ranking in diameter

Diameter growth of tree usually is expressed as D. B. H. (diameter at breast height), but in this study, D. C. H. (diameter at cutting height) was used in order to explain the diameter growth from the initial stage of individual growth.

Figure 3 shows the relationship between the rankings in diameter and tree height.

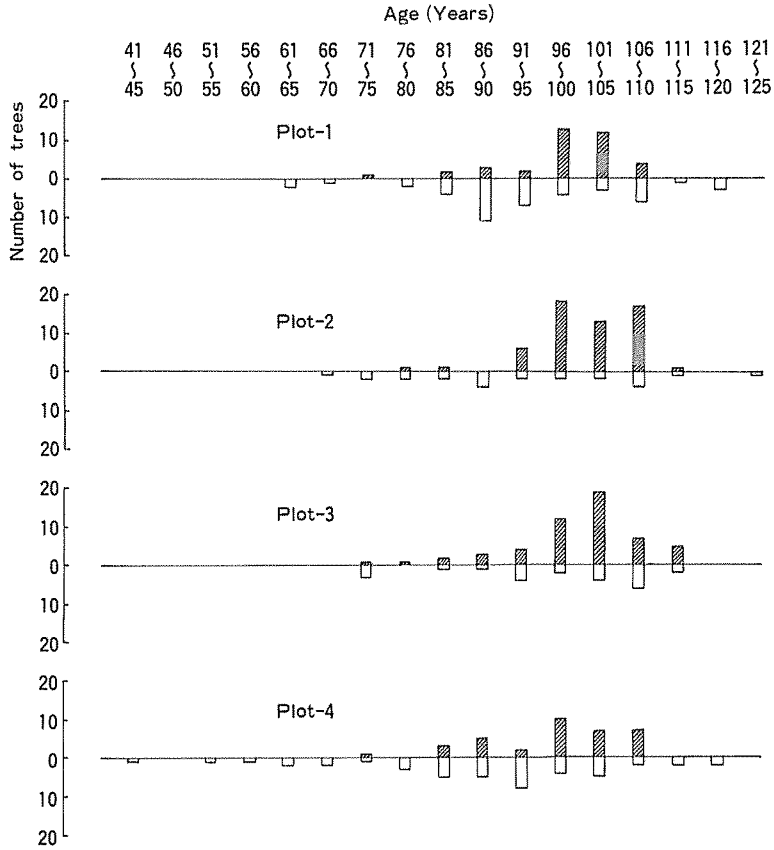


Fig. 1 Frequency of trees in every age class.
▨ : Momi and Tsuga, □ : Broad-leaved tree

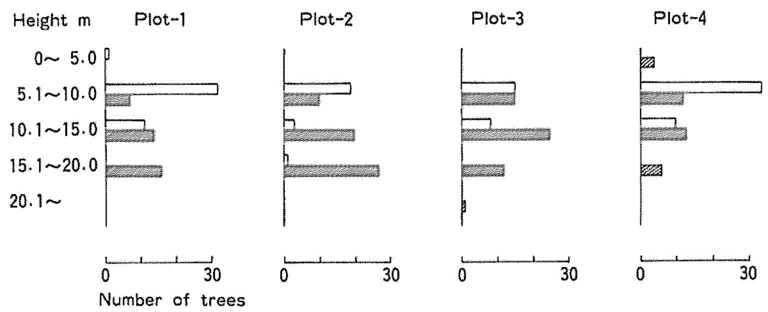


Fig. 2 Frequency of trees in every height class.
▨ : Momi and Tsuga, □ : Broad-leaved tree

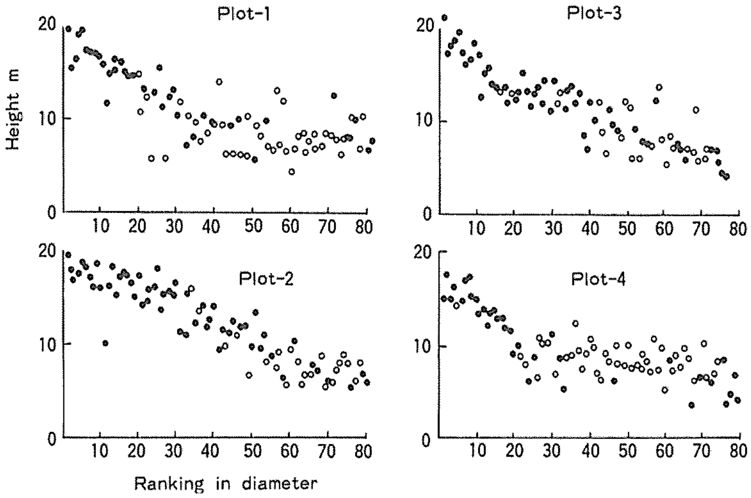


Fig. 3 Relationship between the ranking in diameter and height.
●: Momi and Tsuga ○: Broad-leaved tree

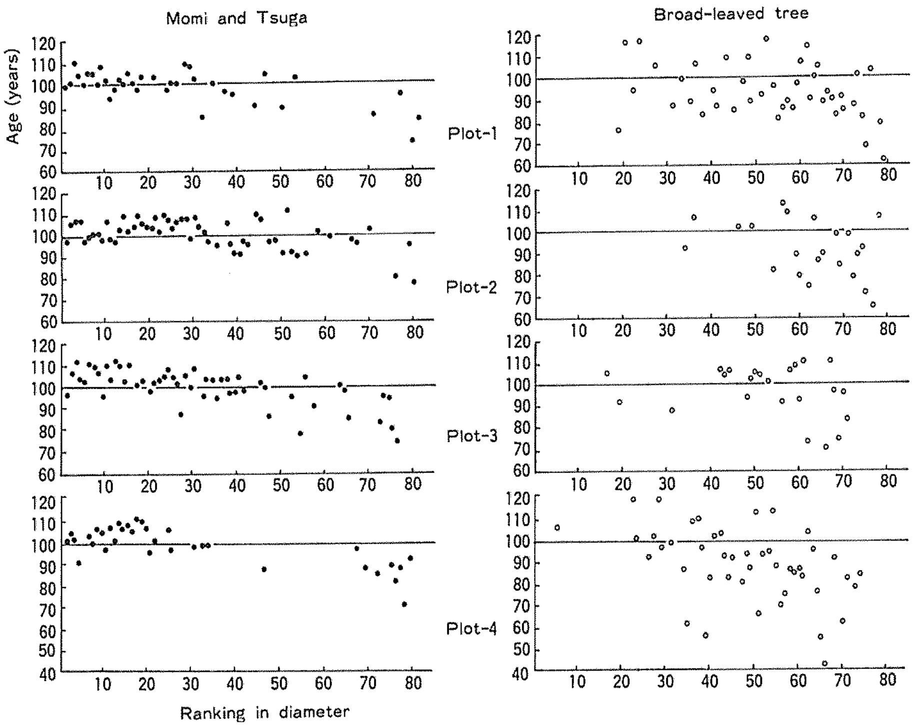


Fig. 4 Relationship between tree ranking and age.
●: Momi and Tsuga ○: Broad-leaved tree

The greater the increase in rank among superior ranking trees were, the greater the height of the trees became, but this phenomenon was not recognized in medium and subordinate ranking trees, most of which were middle-sized or smaller broad-leaved trees, with largely similar heights. These phenomena were evident on plots 1 and 4.

Figure 4 shows the relationship between individual ranking and age. In general, the older the Momi or Tsuga individual, the higher its rank in the plot became, while the younger the individual, the lower the rank. On the other hand, this phenomenon

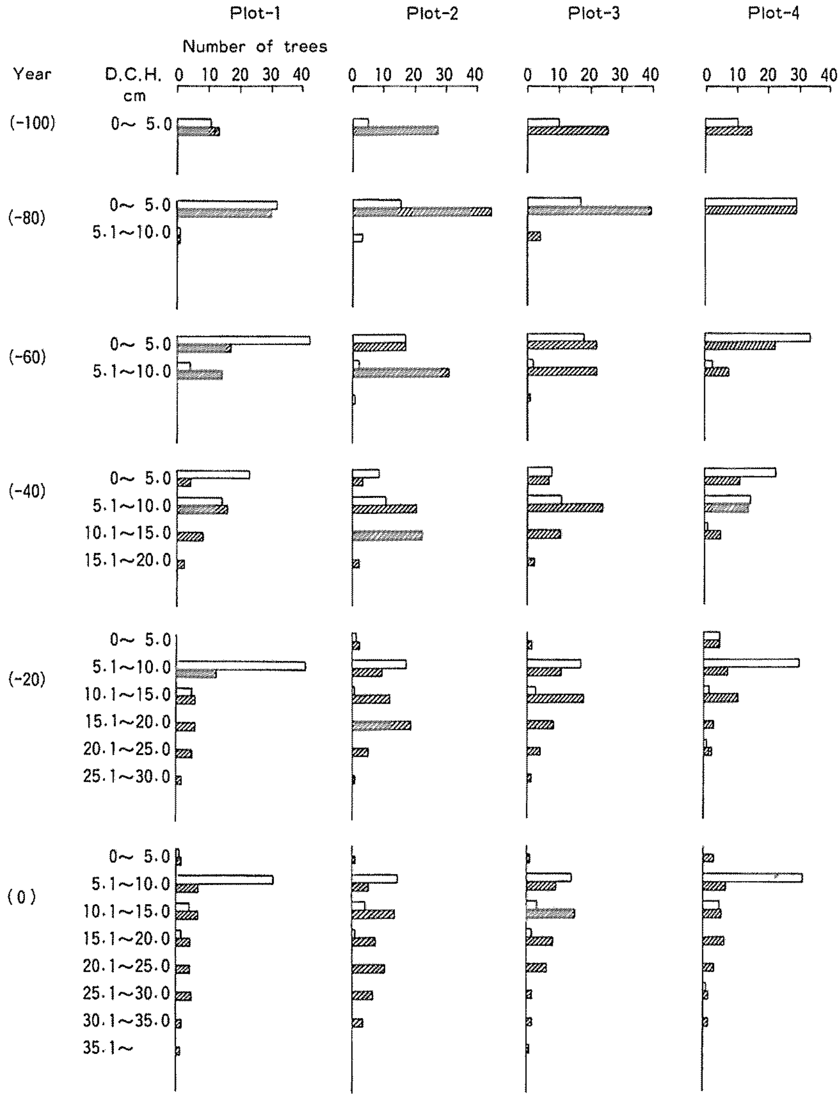


Fig. 5 Frequency of trees in every D. C. H. class.
▨ : Momi and Tsuga, □ : Broad-leaved tree
( ) : Time (year) before cut and surveyed

was not recognized in broad-leaved trees, and the relationship between individual ranking and age varied remarkably in plots 1 and 4 in which the occurrence ratios of broad-leaved trees were higher.

Figure 5 shows the numbers of trees in every diameter class. With the progress of growth, a greater proportion of Momi and Tsuga trees had ranked in the superior class. This phenomenon is shown clearly in Fig. 6, which shows the number of Momi and Tsuga trees, and broad-leaved trees in every ranking class. The number of Momi and Tsuga trees, and of broad-leaved trees ranked in every class varied among the plots. In plots 2 and 3, Momi and Tsuga trees were ranked in the superior class from the initial stage of community formation. On the other hand, in plots 1 and 4, the majority of broad-leaved trees were ranked in the superior class in the initial stage, but with the progress of growth, Momi and Tsuga trees had ranked in the superior class, and broad-leaved trees had been gradually transferred to the medium or subordinate class. In plot 4, a few Momi and Tsuga trees were ranked in the medium class, while most showed a tendency to separate into the superior or subordinate class. This tendency was also shown in plot 1, although it was not recognized in plots 2 and 3. As shown in Table 1, the ratio of each broad-leaved tree to all the trees in plot 1 or 4 was higher than that in plot 2 or 3. Accordingly, it is supposed that the competition between Momi and Tsuga trees and broad-leaved trees was more severe in plots 1 and 4.

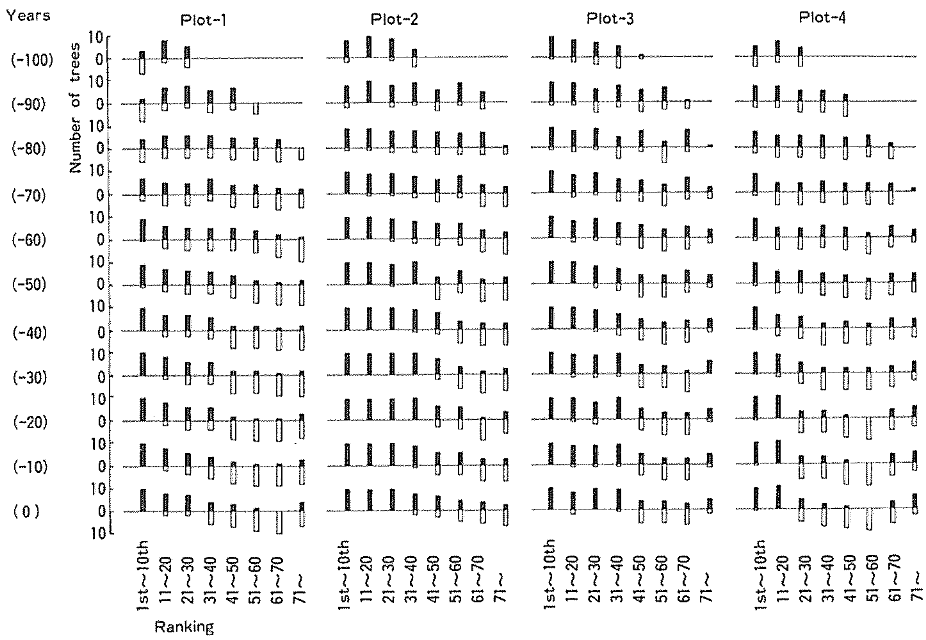


Fig. 6　Frequency of trees in every ranking class.
■ : Momi and Tsuga, □ : Broad-leaved tree
(　) : Years before cut and surveyed

In these plots, because of the oppression of broad-leaved trees, the majority of Momi and Tsuga trees were unable to change to the superior or medium class and stagnated in the subordinate class. That is, some of Momi and Tsuga trees were ranked in the superior class irrespective of the number of broad-leaved trees, but when broad-leaved trees outnumbered Momi and Tsuga trees, those of the latter in the medium-sized class were few, and showed a tendency to separate into the superior class and the oppressed subordinate class.

Individuals ranked in the superior class did not always remain as they were. Figure 7 shows the movements of individual ranking. Most individuals showed a great fluctuation of ranking and individuals in the superior ranks as of 1972 also showed active fluctuation. No differences between Momi and Tsuga trees and broad-leaved trees were recognized with regard to ranking fluctuation. However, with the progress of growth, the fluctuation of Momi and Tsuga trees decreased and the majority of them became stabilized in the superior ranks. On the other hand, most broad-leaved trees were ranked in the medium or subordinate class; moreover, the ranking was still unstable. A small number of large broad-leaved trees were ranked in the superior class, i. e., such species as *Fagus crenata* Blume, *Prunus jamasakura* Sieb. ex Koidz., *Acanthopanax sciadophylloides* Fr. et Sav., and *Kalopanax pictus* (Thunb.) Nakai formed the overstory together with Momi and Tsuga trees.

In this surveyed natural forest, Suzutake grows close to the forest floor. Accordingly, it seemed that Suzutake had grown on the surveyed plot from the initial stage of community development. Previously, we indicated that Suzutake prevents other plants from taking root and is a major biological factor preventing the growth of Momi and Tsuga trees. The relative light intensity in Suzutake communities ranged from 5 to 20% of that at the top of the community (YURUKI *et al.*, 1977), and it usually took from 20 to 30 years for Momi and Tsuga trees to become established in a Suzutake community, out-competing the oppression from Suzutake, due to light insufficiency (YURUKI *et al.*, 1973). However, it was presumed that the surveyed forest had developed in gaps or openings in the forest. On the basis of this presumption, even if Suzutake grew in the gaps, it seems that the relative light intensity in the Suzutake community would have increased so as to exceed that in a natural forest. As mentioned above, Momi and Tsuga trees were ranked in the superior class at an early time in the development of the community. Judging from these phenomena, it is considered that Suzutake did not significantly prevent the growth of Momi and Tsuga trees in these surveyed forests.

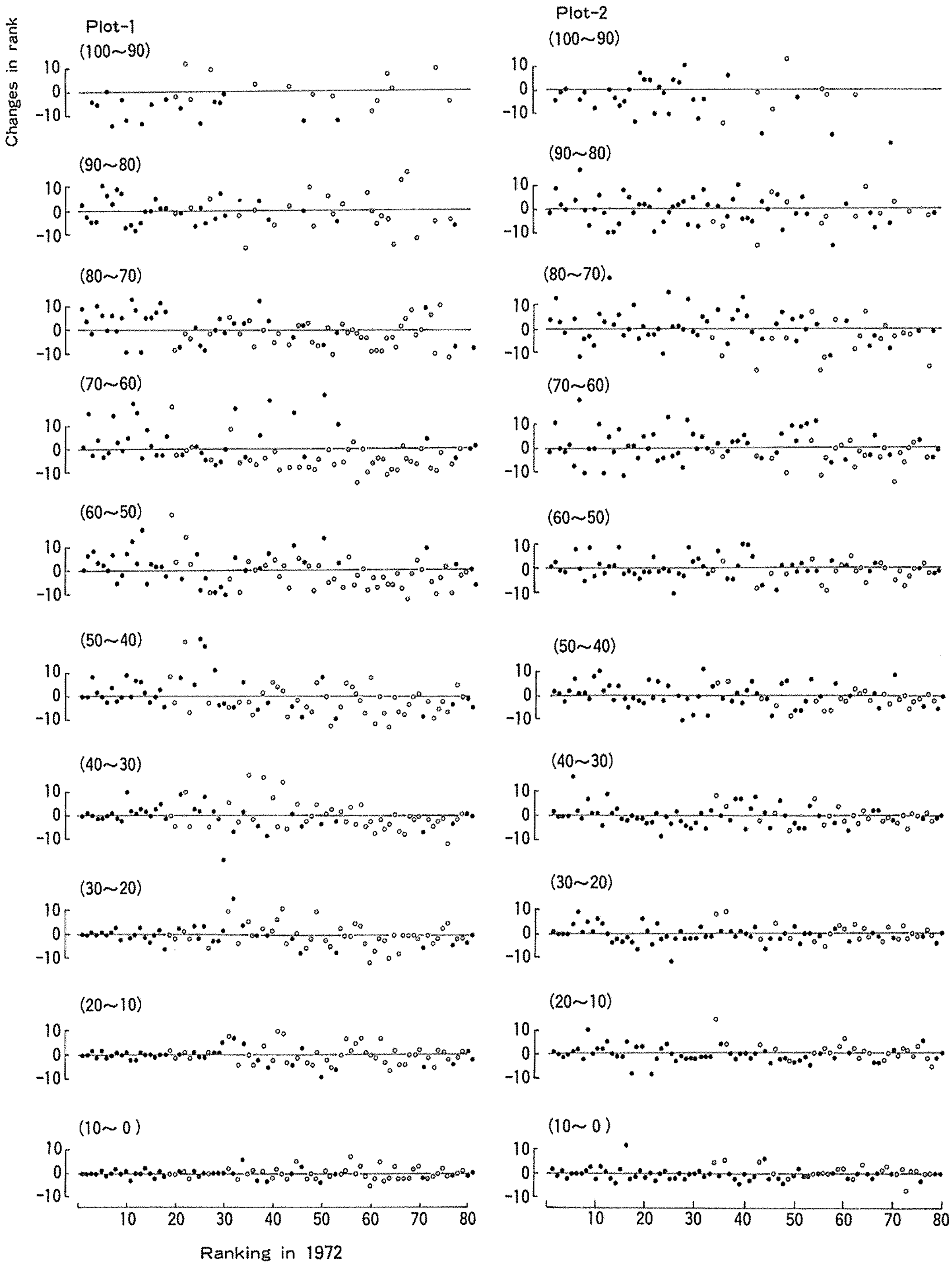


Fig. 7-1　Fluctuation of individual diameter rankings.
●: Momi and Tsuga　　○: Broad-leaved tree
(　): Period before the cutting time (0)

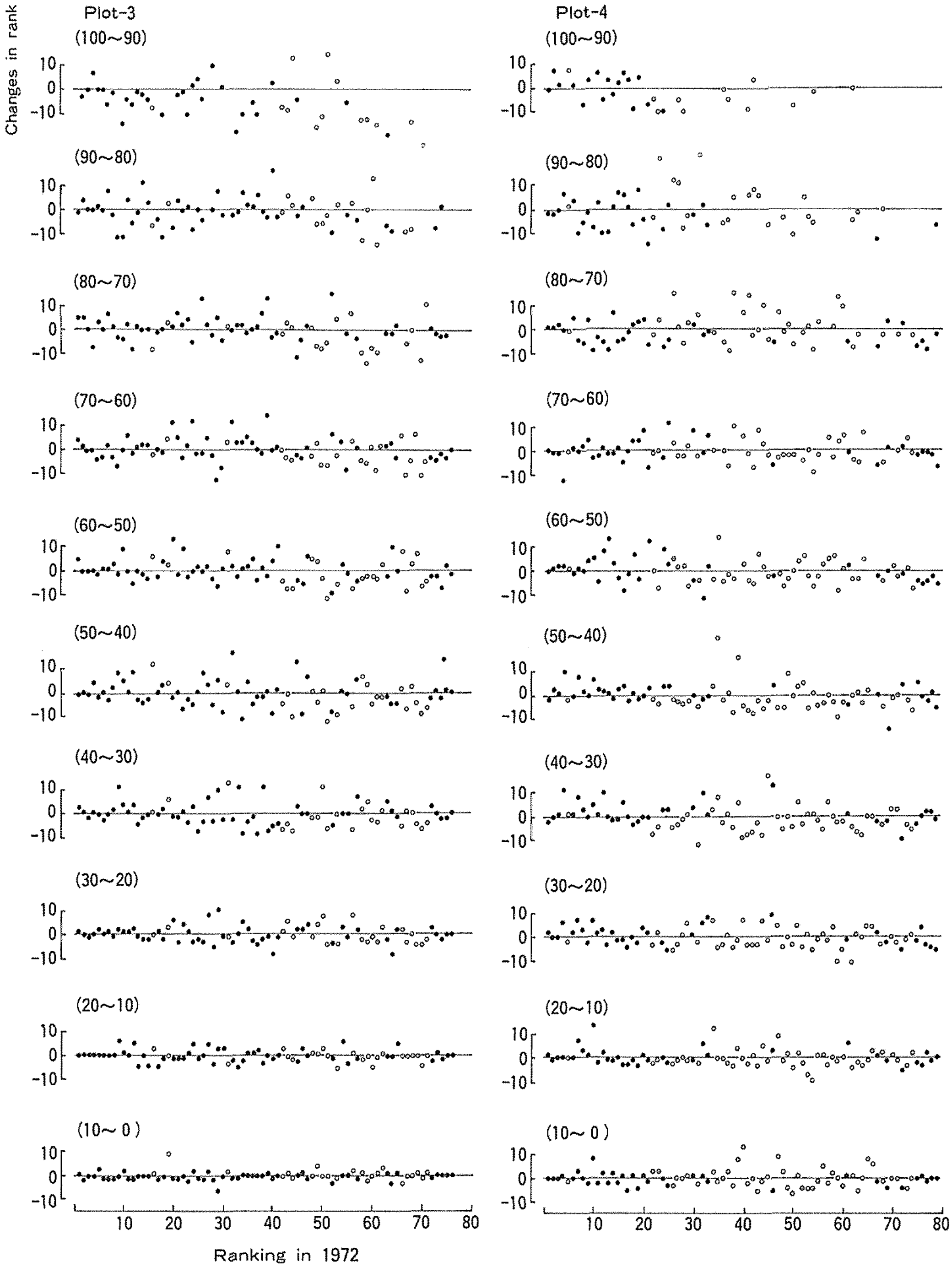


Fig. 7-2 Fluctuation of individual diameter rankings.
●: Momi and Tsuga ○: Broad-leaved tree
( ): Period before the cutting time (0)

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# モミ・ツガ林の発達

## モミ・ツガの生長におよぼす広葉樹の影響

汰 木 達 郎・荒 上 和 利

## 要　　旨

本論文では共存する広葉樹を含む全個体の順位変動によって，モミ・ツガの生長におよぼす広葉樹の影響を群落形成の初期の段階から検討した．

1) 年齢構成から判断して，調査したモミ・ツガ林は林内のギャップに発達したと考えられた．

2) 早く発生したモミ・ツガは，広葉樹にたいして比較的早い時期に優位に立ち，上位に安定している．

3) 一方遅く発生したモミ・ツガの大部分は被圧によって下位に停滞している．このことは発生の時期がその後の生長を左右していることを示唆している．

4) モミ・ツガ林では，モミ・ツガ個体は上，中，下の3つのクラスに順位分けられるが，広葉樹が多い場合には，中位木は少なく，上位と下位の2クラスに分離する傾向がみられた．

5) 広葉樹の樹種構成をみると高木性のものが少なく，中・低木性のものが大部分であり，この高木性の広葉樹の少ないことも，モミ・ツガの優位を容易にさせた要因の1つであると考えられた．