Matter-economical Roles of Evergreen Leaves in
*Aucuba japonica*, an Understory Shrub in
the Warm-temperate Region of Japan

2. Dynamics and Budgets of Nutrients

Yasuo Yamamura* and Makoto Kimura**

*Department of Biology, Faculty of Science,
Ibaraki University, Mito, 310 Japan
**Department of Biology, Faculty of Science, Tokyo Metropolitan University, Hachioji, 192-03 Japan

Seasonal dynamics in nitrogen and phosphorus content were examined for each component organ of *Aucuba japonica*, an evergreen understory shrub in the warm-temperate region of Japan. Evergreen foliage was the largest pool for each nutrient; nitrogen and phosphorus were accumulated and stored in autumn and then redistributed in the spring. For individual leaves, such seasonal accumulations and redistributions were repeated through two or three years and then at leaf fall, an additional amount was withdrawn. Rapid growth of new shoots and flowers during spring was supported by the massive redistribution of the nutrients from the old foliage. The redistribution accounted for 85% and 65% of the total nitrogen and phosphorus input to the new shoots, respectively. Such a high ratio of redistribution resulted in a conservative nutrient economy, and must be positively related to the photosynthetic production in the light-limited environment.

Key words: *Aucuba japonica* — Evergreen leaves — Nitrogen — Nutrient economy — Phosphorus — Shade-tolerant shrub

In most perennial plants, the seasonal course of the uptake of nutrients from the soil is not parallel to the seasonal course of new growth. Rapid spring growth of plants is usually supported more by stored nutrients than by concurrent absorption (Chapin, 1980). Seasonal storage and redistribution of nutrients must be essential processes in the nutrient economy of these plants.

Leaves of evergreen plants can serve as sites of nutrient accumulation and storage (Chapin, 1980; Chabot and Hicks, 1982). The accumulation of nutrients into leaves and the redistribution of the nutrients have been observed in various types of evergreen plants such as conifers (Krueger, 1967; Mutoh, 1968; Meyer and Splittstoesser, 1971; Fife and Nambiari, 1982, 1984; Tyrrell and Boerner, 1987), broadleaf trees (Kimura et al., 1983), shrubs (Hadlay and Bliss, 1964; Mooney and Rundel, 1979; Gray, 1983) and herbs (Kimura, 1983). For these plants, nutrients required for the growth of new shoots should depend more or less on the translocation from the leaves. In a warm-temperate broadleaf tree, an evergreen foliage is a dominant source of
nitrogen for the new shoots (Kimura et al., 1983).

The pattern of the nutrient accumulation and redistribution must be associated with the environmental condition of the habitat. For an evergreen chaparral shrub occurring on infertile habitats, Mooney and Rundel (1979) showed that the foliage provided a sink for nitrogen and phosphorus taken up from the soil during the rainy nongrowth season and a source of nutrients needed for new growth in the subsequent dry season. In forest understory, the light seems to be the most dominant limiting factor for plant existence. Therefore the pattern of nutrient economy of evergreen understory plants, which has only scarcely been examined, should be closely related to the light-limited condition.

*Aucuba japonica* Thunb. (Cornaceae) is a typical shade-tolerant shrub in the warm-temperate forest of Japan. For this shrub, the accumulation of dry matter in leaves from autumn to budbreak in spring and its consumption during growth of new shoots have been observed (Yokoi and Kishida, 1985; Yamamura, 1986). The previous paper (Yamamura, 1986) evaluated quantitatively the accumulation and consumption of dry matter in the foliage. In the present paper we analyze the seasonal dynamics and the annual budgets of nutrients to clarify the roles of evergreen foliage in the nutrient economy in relation to the light-limited environment.

**Materials and Methods**

The study site was in the Tokyo University Forest in Chiba, located in southern Boso Peninsula in Central Japan. Field surveys and samplings were done for an *A. japonica* population in an artificial forest of *Chamaecyparis obtusa*, an evergreen conifer.

The shrub is an evergreen and dioecious plant. The leaves of the shrub are relatively large and long-lived. The mean life span of the leaves was 2.6 years in the study site (Yamamura, 1986). After budbreak in early April, most of the visible activities such as flowering, leaf expansion and leaf fall are performed during spring. The age of the leaves and the stems can be easily determined from the scars of the winter buds.

Male plants were used for this examination, because female plants must differ from each other significantly in allocation of matter owing to the variable production of fruit. Samples were selected from reproductive plants of a similar size, about 2 m in height and 2.3 to 3.0 cm in stem diameter at the ground level. At least three aerial parts and two subterranean parts were periodically harvested over a period of a year starting from spring 1982.

The aerial parts were subdivided into leaves, buds, flowers, branches and trunks. The leaves were further sorted into each yearly cohort. The branches were divided into current-year parts, 1- and 2-year old parts and the parts older than two years. The subterranean parts were divided into fine roots (smaller than 5 mm in diameter) and coarse roots (larger than 5 mm). The emergence of new roots was observed mainly from late summer to early autumn. Although it was impossible to distinguish