Karyomorphological Studies of *Cladopus nymani* H. Moll. and *Indotristicha malayana* Dransf. et Whitmore (Podostemaceae sensu lato) from Malesian Wet Tropics

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マレーシア湿潤熱帯産カワゴケソウ科植物2種 *Cladopus nymani* と *Indotristicha malayana* の核形態学的研究

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Karyomorphological characteristics of *Cladopus nymani* and *Indotristicha malayana* belonging to the rheophitic family, Podostemaceae, were observed. Both species showed the prochromosome type karyomorphology. Chromosome number of *C. nymani* was $2n = 30$, while *I. malayana* $2n = 20$. Chromosome complement of the former species suggests the basic chromosome number of the family is $x = 5$, but not $x = 10$.

All species of the family Podostemaceae are exclusive rheophitic plants forming crust-like root (or thallus) system and growing restrictively on rocks under rapid streams in tropical or subtropical regions (Steenis 1981, 1987). The phylogenetic status of this extremely peculiar family is not ascertained yet. Most investigators consider that the family is related to the Saxifragaceae and Crassulaceae (Cronquist 1981). On the other hand, Cusset & Cusset (1988) propounded a new class, the Podostemopsida, which is constituted of the order Podostemales and the families Tristichaceae and Podostemaceae, beside the Magnoliopsida and the Liliopsida.

Knowledge of the chromosomes plays an important role in understanding the relationship between groups (for examples, Okada 1986, Okada & Tamura 1979, Okada & Tanaka 1975). During the period of more than half a century since Chiarugi's observations (1933), there has been no information about chromosome characteristics of the Podostemaceae. I have had a chance to approach these interesting plants at Malesian wet tropics and observed their chromosome characteristics. This report aims to add more to the poor karyomorphological information which is an important tool for understanding the phylogenetic status of the family.
Materials and Methods

Fresh material of *Cladopus nymani* H. Möll. was collected from Sg. (river) Pa Raya, about 1100 m alt., 4°N 115°40–45'E, about 10 km north from Long Bawan, Krayan County, East Kalimantan (Indonesian Borneo), Indonesia (cf. Iwatsuki et al. 1983) on 18th September, 1990. This river passes through the mountainous regions at the border between Malaysia (Sabah) and Indonesia, and is surrounded by well developed primary forests. The width of the river at the habitat is ca. 30 m. Plants grow on rocks under rapid water flow, and expand up to a radius of about 50 cm. Water is usually clear, but becomes muddy after heavy rain fall. Water temperature at the habitat was ca. 23°C at 2:30 pm. Plants were found at several sites along the river.

Another material, *Indotrithicha malayana* Dransf. et Whitmore, was collected from Sg. Kenyam, ca. 100 m alt., 4°32'N 102°28'E, a branch river of Sg. Tembeling, Taman Negara, Pahang, Malaysia on 24th August, 1990. This river is surrounded by well-protected primary dipterocarp forests. The width of river at the habitat is ca. 20 m. Plants grow on stones of 20–50 cm in diameter under rapid water flow, and expand up to a radius of about 20 cm. Stones were anchored by network of the nests of some aquatic insects or other worms. Water was clear and its temperature at the habitat was ca. 26°C at 10:30 am. Plants were rather common along the river.

Well growing root (or thallus) tips of the specimens were pretreated by 0.05% colchicine aqueous solution at 18–20°C for 3–4 hours. Lower temperature in the field was obtained by making use of the dissolution of ammonium nitrate (NH₄NO₃) in a thermos. Materials were transferred into Carnoy's fluid (95% EtOH: acetic acid = 3:1) and stored in the same fluid. They were carried to the laboratory and transferred into 45% acetic acid for several minutes, and then treated by the Feulgen’s reaction. Meristematic tissues of root tips were picked up on slide glass and stained again by 2% aceto-orcein for 10 minutes, and then squashed.

Voucher specimens were kept in the University of Tokyo (TI).

Results and Discussion

*Cladopus nymani* H. Möll.: Somatic chromosome number of the specimen was observed to be 2n = 30 (Figs. 2–4). The interphase nuclei contained several darkly stained round-or rod-shaped pycnotic bodies and weakly and granularly stained chromatin (Fig. 1). The size of the pycnotic bodies varied. At prophase chromosomes, heterochromatic segments were distinguishable from euchromatic ones and were distributed at proximal parts of arms (Fig. 2). The boundary of both segments showed clear cut connection. Chromosome size at metaphase ranged from ca. 2μm to 0.5μm (Figs. 3, 4). These karyomorphological characteristics suggest that the specimen is categorized under the prochromosome type nucleus (Tanaka 1971).

The chromosome complement at metaphase seemed to be bimodal in size. There were 8 pairs of bigger chromosomes and 7 pairs of smaller ones. Among the chromosomes one pair of metacentric satellite chromosome, the biggest pair (Figs. 3 and 4), and one pair of the smallest telocentric chromosome were conspicuous, while the rest formed rather identical pairs. These facts suggest that the chromosome complement consists of two sets, but not three sets (Fig. 4). The specimen is not of autotriploid level, but may be of diploid level induced by the diploidization of some high ploidy level, i.e. hexaploid. The properties of the species support this idea. Individuals of the species
Figs. 1–3. Photomicrographs of somatic interphase nucleus (1), prophase (2) and metaphase (3) chromosomes of *Cladopus nymani*, 2n = 30. Arrows in Fig. 3 indicate satellite chromosome. Bar, 5 μm.

Fig. 4. Chromosome complement of *Cladopus nymani*, 2n = 30. Bar, 2 μm.
were distributed at separate rocks here and there and/or at separate places along the river. They may propagate in the habitat by seeds but not vegetatively. Triploid plants can not produce fertile seeds, except by the way of an agamospermous reproduction. Embryological studies of this species is necessary.

Indotristicha malayana Drans. & Whitmore (= Malaccotristicha malayana (Drans. & Whitmore) C. & G. Cusset): Somatic chromosome number of the specimen was 2n = 20 (Figs. 6, 7). The morphological characteristics of the interphase nuclei and prophase chromosomes were almost the same as the former species (Figs. 5, 6). Chromosome size at metaphase ranged from ca. 2 μm to 0.8 μm (Fig. 7).

On the basis of the reported chromosome numbers of the family [2n = 20, Dalzella ceylanica (Gardn.) Wight (= Lawia zeylanica (Gardn.) Tul.) (Magnus 1913), and 2n = 40, Podostemum subulatus Gardn. (Magnus 1913) and Weddellina squamulosa Tul. (Chiarugi 1933)], the basic chromosome number of the family has been presumed to be x = 10 (Cronquist 1981). However, the results of C. nymani suggest that the basic chromosome number of the family is x = 5. The chromosome numbers, 2n = 20, 30 and 40, may be of tetraploid, hexaploid and octaploid level, respectively.

Both genera studied in this report belong to different groups, i.e., Cladopus to Podostemoideae and Indotristicha to Tristichoideae (Melchior 1964). According to the fact that both genera showed similar karyomorphological characteristics, the family possibly has the prochromosome type nuclei. Further karyomorphological studies are to be undertaken on the Podostemaceae distributed in Africa and America.

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References


要 旨

カワゴケソウ科に属する全ての植物は渓流に洗われる岩上に生育している渓流植物で、温潤熱帯を中心に約40属200種が分布している（Cronquist 1981）。日本では主に鹿児島県でカワゴケソウ、カワゴロモなど数種が知られている。この植物群の系統的な位置関係はよくわかっていないが、ユキノシタ科、ベンケイソウ科などとの類縁が考えられている（Cronquist 1981）。最近、双子葉植物、単子葉植物網の他に新しくカワゴケソウ植物網をたてる意見もでている（Cusset and Cusset 1988）。

染色体の示す諸形質はその植物群の系統類縁関係を明らかにしていく上で重要な役割を果たす場合があるが、カワゴケソウ科植物の染色体に関する報告は今から50年以上前に報告があるだけで以降まったくない。1990年マレー半島と東カリマンタンで行われた渓流植物の系統進化学的研究のための学術調査に参加した際、Cladopus nymani H.Möll.と Indotrictistcha malayana Dransf. et Whitmore (= Malaccotrichistcha malayana (Dransf. & Whitmore) C. et G. Cusset) の2属2種
のカワゴケソウ科植物に接する機会があり、核形態を観察する事が出来た。本報告ではカワゴケソウ科の系統関係のより正しい理解のための基礎資料の1つとして、これらの植物の核形態学的特徴を記載した。

両種とも前染色体型の核形態学的特徴を示した（Figs. 1–3, 5–7）。染色体数は C. nymani が 2n = 30（Figs. 2–4）、I. malayana が 2n = 20（Figs. 6, 7）であった。カワゴケソウ科の染色体数は2n = 20と40が知られ、科の染色体基本数はx = 10と考えられてきた（Cronquist 1981）。しかし、今回観察した C. nymani (2n = 30) の染色体組成を見ると2本づつの対を形成するようにみられ（Fig. 4）、本種をx = 10の3倍体とは考えにくい。むしろカワゴケソウ科の染色体基本数はx = 5であると考えられる。