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# Comparative Karyotype Analysis in Five Strains of *Colocasia esculenta* (L.) Schott (Araceae) in Thailand

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**Summary** Cytogenetical studies were carried out on *Colocasia esculenta* (L.) Schott and five different karyotypes were observed, karyotype formula of each karyotype were $2n=28=L^{m}_{24}+M^{sm}_{4}$, $2n=28=L^{m}_{14}+L^{sm}_{2}+M^{m}_{6}+M^{sm}_{6}$, $2n=28=L^{m}_{22}+L^{sm}_{6}$, $2n=28=L^{m}_{18}+M^{m}_{4}+M^{sm}_{2}+S^{sm}_{2}+S^{sm}_{2}$ and $2n=28=L^{m}_{8}+L^{sm}_{4}+M^{m}_{4}+M^{sm}_{10}+S^{m}_{2}$. The karyotype of five strains had same chromosome number of $2n=28$ and fundamental number (NF)=56. Therefore, all of the five strains had a symmetrical karyotype that consisted of metacentric and submetacentric chromosomes. The differences among karyotypes were caused by number of metacentric and submetacentric chromosomes. The chromosome number of *C. esculenta* had been reported, but this is the first report of karyotype variation among strains.

**Key words** Araceae, *Colocasia*, Chromosome, Karyotype variation, Idiogram.

The genus *Colocasia* Schott (Araceae) includes about 20 species that are mainly distributed from the subtropical eastern Himalayas throughout subtropical and tropical Asia to the tropical western pacific, the Polynesian islands, eastern Australia and parts of Africa (Li and Boyce 2010, Boyce and Sookchaloem 2012). Wild taros distribute between Bangladesh and Myanmar (Kreike *et al*. 2004).

The *Colocasia* in Thailand is found in humid areas, as a weed in roadside ditches, wet fields, brooks, waterfronts, swamps, canals and marshes, and includes four species *C. esculenta* (L.) Schott, *C. fallax* Schott, *C. gigantea* (Blume) Hook. F. and *C. menglaensis* J. T. Yin, H. Li & Z. F. Xu. There are two species, *C. esculenta* and *C. gigantea* that are traditionally used as medicine and food (Sreekumari and Mathew 1991a, Beevi 2013). *C. esculenta* are distributed throughout tropical and subtropical Asia. One cultivar of *C. esculenta* had tremendous economic significance since time immemorial, but taxonomy of the genus is still poorly known (Gogoi and Borah 2013). *C. esculenta* is an important edible plant and the petiole and young leafy parts are used for foods. During a survey to collect Araceae specimens, we found five strains of *C. esculenta* with different morphological forms.

The chromosome number of *C. esculenta* has been reported (Simmonds 1954). The cytological studies of *C. esculenta* mainly associated with comparison among different populations and, their variations in chromosome number and karyotypes. In this study we performed a comparative karyotype analysis among newly found five strains of *C. esculenta* in Thailand.

## Materials and methods

Five strains of *C. esculenta* (L.) Schott were collected from the field (Table 1) and grown in a nursery at the Walai Rukhavej Botanical Research Institute, Mahasarakham University. All voucher specimens were deposited at Mahasarakham University, Thailand.

To determine the chromosome number, karyotype analyses were performed. A root tips were pretreated in 2 mM 8-hydroxyquinoline at 4°C for 8 h, fixed in ethanol : acetic acid (3 : 1, v/v) at room temperature for 30 min and stored at 4°C or immediately used. Samples were washed in distilled water, hydrolyzed in 1 M HCl at 60°C for 5 min and washed in distilled water. The root tips were stained in 2% acetoorcein, and then they were squashed and sealed for observation under a microscope. Karyomorphological observations were made on chromosomes at the resting stage, mitotic prophase and metaphase, and their classification followed Tanaka (1971, 1977). Karyotype formulas were derived from measurements of the metaphase chromosomes from photomicrographs. The nomenclature used to describe the karyotype followed Levan *et al.* (1964). The classification of the karyotype asymmetry follows Stebbins (1971).

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**Table 1.** Comparative analysis on morphological characteristics in five strains of *C. esculenta* in Thailand.

| Stains | Characteristics | | | | | | | | Thai name (Collector No.) |
|---|---|---|---|---|---|---|---|---|---|
| | Leaf blade peltate | Petiole | Leaf margin | Leaf color | Leaf texture | Latex | Edibility for human | Past used | |
| 1 | Ovate-cordate to sagittate | Light green | Undulate | Light green | Chartaceus | Itchy | No | No | Bon-Kun (R. Senavongse 001/2015) |
| 2 | Ovate-cordate to sagittate | Light green | Undulate | Bright green | Coriaceus | No itchy | Yes | P, YL | Bon-Jeud (R. Senavongse 006/2015) |
| 3 | Ovate-cordate to sagittate | Dark purple | Undulate | Dark green | Chartaceus | No itchy | No | No | Bon-Kandum (R. Senavongse 011/2015) |
| 4 | Oblong-cordate | Dark green | Non-Undulate | Dark green | Succulent | No itchy | No | No | Bon-Dum (R. Senavongse 016/2015) |
| 5 | Oblong-cordate | Dark green | Non-Undulate | Dark green | Succulent | No itchy | Yes | P, YL | Bon-Hwan (R. Senavongse 021/2015) |

P=Petiole; YL=Young leafy.

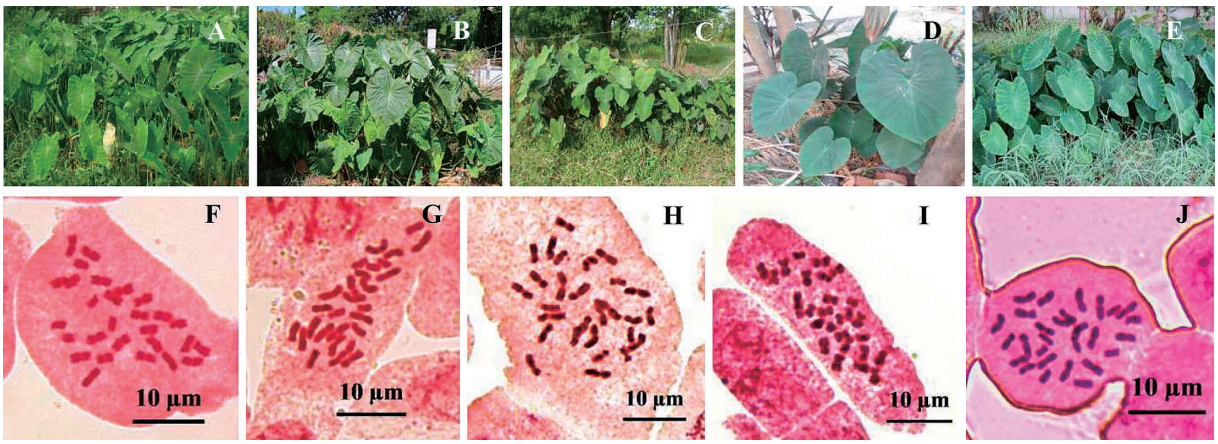



**Fig. 1.** Plant forms of the five strain of *C. esculenta*, A: strain 1, B: strain 2, C: strain 3, D: strain 4, E: strain 5. Somatic metaphase chromosomes of the five strains, F: strain 1, G: strain 2, H: strain 3, I: strain 4, J: strain 5.

## Results and discussion

The characteristics of the five strains of *C. esculenta* were described in Table 1 and shown in Fig. 1A–E. The karyomorphological characteristics of the five strains were described and summarized in Table 2 and shown in Figs. 1F–J and 2. The diploid chromosome number was $2n=28$ and NF=56 in all five strains (Fig. 2). This is the new karyotype and idiogram report in this species. The karyotype formulas of five strains of *C. esculenta* are as follows:

Strain 1: $2n = 28 = L^{m}_{24} + M^{sm}_{4}$

Strain 2: $2n = 28 = L^{m}_{14} + L^{sm}_{2} + M^{m}_{6} + M^{sm}_{6}$

Strain 3: $2n = 28 = L^{m}_{22} + L^{sm}_{6}$

Strain 4: $2n = 28 = L^{m}_{18} + M^{m}_{4} + M^{sm}_{2} + S^{m}_{2} + S^{sm}_{2}$

Strain 5: $2n = 28 = L^{m}_{8} + L^{sm}_{4} + M^{m}_{4} + M^{sm}_{10} + S^{m}_{2}$

The chromosome numbers and karyotypes of *C. esculenta* were summarized in Table 3. Karyotypes varied in composition of each chromosome shape among five strains in Fig. 2.

The chromosome number of *C. esculenta* ($2n=28$) agrees with majority of previous reports (Table 3). The chromosome complements *C. esculenta* of strain 1 (Fig. 2A, B) and strain 4 (Fig. 2G, H) had 24m+4sm karyotype formula (Table 3), which consisted of 12 pairs of metacentric chromosomes and two pairs of submetacentric chromosomes, as the same with report of Parvin *et al.* (2008) in cytotype 5. In strain 2 (Fig. 2C, D) was 20m+8sm (Table 3), which consisted of 10 pairs of metacentric chromosomes and four pairs of submetacentric chromosomes, was found to have five chromosome pairs 1, 2, 6, 7, 12 that possessed satellites, as the same with Sreekumari and Mathew (1991a) in type (I), but this was not the same as in the report of Okada and Hambali (1989) who found only one pair. In strain 3 (Fig. 2E, F) that had the 22m+6sm karyotype formula (Table 3) and consisted of 11 pairs of metacentric chromosomes and three pairs of submeta-centric chromosomes, was found to have five chromosome pairs 1, 2, 3, 6, 12 that possessed satellites, which was consistent with the report of Parvin *et al.* (2008) in cytotype 7, but this was not the same as in the report of Okada and Hambali (1989) who found only one pair. In strain 5 (Fig. 2I, J) that had the 14m+14sm karyotype formula (Table 3) and consisted of seven pairs of metacentric chromosomes and seven pairs of submetacentric chromosomes, which

**Table 2.** Comparative karyotype analysis in five strains of *C. esculenta* in Thailand.

| Strains | 2*n* | NF | Karyotype formula | No. of satellites | Location of satellite |
|---|---|---|---|---|---|
| 1 | 28 | 56 | 24m+4sm | — | — |
| 2 | 28* | 56 | 20m+8sm | 10 | 8(SCR), 2(STR) |
| 3 | 28* | 56 | 22m+6sm | 10 | 10(SCR) |
| 4 | 28 | 56 | 24m+4sm | — | — |
| 5 | 28 | 56 | 14m+14sm | — | — |

m=metacentric chromosome; sm=submetacentric chromosome. *Strain which has satellite chromosomes, SCR=subcentromeric region and STR=subtelomeric region.

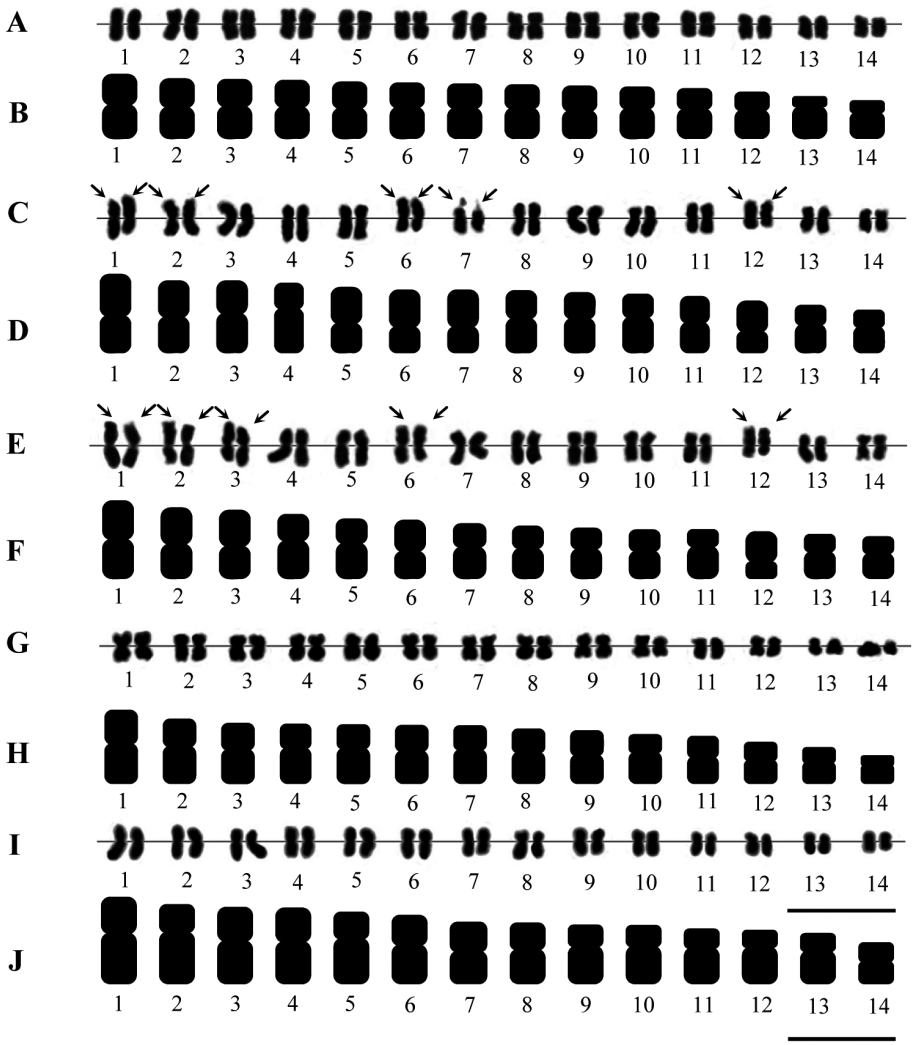



**Fig. 2.** Karyotype and idiogram of five strains of *C. esculenta*. Karyotype and idiogram of strain 1 (A, B), of strain 2 (C, D), strain 3 (E, F), strain 4 (G, H) and strain 5 (I, J). Arrows indicate satellites. Scale bar=10 $\mu$m for karyotype and scale bar=20 $\mu$m for idiogram.

was not consistent with previous reports. The five strains of *C. esculenta* have symmetrical karyotype in this study. However, there are some reports of chromosome counts that are different from 2*n*=28, such as 2*n*=22, 26, 38 (Sharma and Sarkar 1963) and 2*n*=42 (Ramachandran 1978). Some of these could be aneuploid variants of 28 and 42 (Yen and Wheeler 1968, Bai *et al.* 1971, Kawahara 1978, Ramachandran 1978, Zhang and Yang 1984, Tanimoto and Matsumoto 1986, Coates 1988, Sreekumari and Mathew 1989). Therefore, *C. esculenta* is the only species in *Colocasia* with various chromosome numbers. The karyomorphological characters of this species studied here were almost the same as each other, such as the chromosome complements only consisting of metacentric and submetacentric chromosomes or the symmetrical karyotype in the five strains of *C. esculenta*. However, there are differences in the numbers of metacentric and submetacentric chromosomes as well as satellite chromosomes among the strains, which are found on the satellite chromosomes of the strains 2 and 3

**Table 3.** Cytogenetic reviews of *C. esculenta*, Araceae.

| 2*n* | NF | Karyotype formula | Satellite | Location | Reference |
|---|---|---|---|---|---|
| 28 (7 varieties) | — | — | — | Trinidad | Simmonds (1954) |
| 28 (10 varieties) | — | — | — | America | Jones (1957) |
| 22, 26, 38 | — | — | — | China | Sharma and Sarkar (1963) |
| 28, 42 | — | — | — | Australia | Yen and Wheeler (1968) |
| 28 | — | — | — | Canada | Marchant (1971) |
| 28, 42 | — | — | — | India | Bai *et al.* (1971) |
| 28, 42 | — | — | — | India | Kawahara (1978) |
| 28 (7 varieties) | — | — | — | India | Ramachandran (1978) |
| 42 (10 varieties) | — | — | — | India | Ramachandran (1978) |
| 28, 42 | — | — | — | China | Zhang and Yang (1984) |
| 28, 42 | — | — | — | Japan | Tanimoto and Matsumoto (1986) |
| 28, 42 | 56, 84 | — | — | Australia | Coates *et al.* (1988) |
| 42 | 84 | — | — | India | Subramanian and Munian (1988) |
| 36 | — | — | — | China | Huang *et al.* (1989) |
| 28 | — | — | — | India | Kuruvilla *et al.* (1989) |
| 28 | — | — | — | China | Li (1989) |
| 28 | 56 | — | 2(SCR) | Indonesia | Okada and Hambali (1989) |
| 28, 42 | — | — | — | India | Sreekumari and Mathew (1989) |
| 28 (I) | 56 | 20m+8sm | — | India | Sreekumari and Mathew (1991a) |
| 28 (II) | 56 | 20m+6sm+2a | — | India | Sreekumari and Mathew (1991a) |
| 28 (III) | 56 | 18m+8sm+2a | — | India | Sreekumari and Mathew (1991a) |
| 28 (IV) | 56 | 22m+2sm+6a | — | India | Sreekumari and Mathew (1991a) |
| 28 (V) | 56 | 6m+12sm+10a | — | India | Sreekumari and Mathew (1991a) |
| 28 | — | — | — | India | Sreekumari and Mathew (1991b, c) |
| 42 | — | — | — | China | Zhang (1998) |
| 28 | — | — | — | New Caledonia | Ivancic and Lebot (1999) |
| 28 (Cytotype 1) | 56 | 18m+6sm+4a | — | Bangladesh | Parvin *et al.* (2008) |
| 28 (Cytotype 2) | 56 | 20m+4sm+4a | — | Bangladesh | Parvin *et al.* (2008) |
| 42 (Cytotype 3) | 84 | 38m+4sm | — | Bangladesh | Parvin *et al.* (2008) |
| 21 (Cytotype 4) | 42 | 12m+2sm | — | Bangladesh | Parvin *et al.* (2008) |
| 28 (Cytotype 5) | 56 | 24m+4sm | — | Bangladesh | Parvin *et al.* (2008) |
| 28 (Cytotype 6) | 56 | 28 m | — | Bangladesh | Parvin *et al.* (2008) |
| 28 (Cytotype 7) | 56 | 22m+6sm | — | Bangladesh | Parvin *et al.* (2008) |
| 26, 30, 36, 38, 44, 46, 48, 52, 58, 84, 116 | — | — | — | China | Li and Boyce (2010) |
| 28, 42 | — | — | — | China | Huang *et al.* (2012) |
| 28 (strain 1) | 56 | 24m+4sm | — | Thailand | Present study |
| 28 (strain 2) | 56 | 20m+8sm | 8(SCR), 2(STR) | Thailand | Present study |
| 28 (strain 3) | 56 | 22m+6sm | 10(SCR) | Thailand | Present study |
| 28 (strain 4) | 56 | 24m+4sm | — | Thailand | Present study |
| 28 (strain 5) | 56 | 14m+14sm | — | Thailand | Present study |

m=Metacentric chromosome, sm=submetacentric chromosome, a=acrocentric chromosome, t=telocentric chromosome, st=subtelocentric chromosome, STR=subtelomeric region, SCR=subcentromeric region, —=not determined.

that showed diversity not only in the chromosome number but also in karyotypes. Therefore, the karyotypes can be compared among the five strains for *C. esculenta*.

The five strains studied here were almost the same as each other in the feature of chromosomes, such as the chromosome complements only consisting of metacentric and submetacentric chromosomes and karyotype asymmetry of the five strains. However, there are differences in the numbers of metacentric and submetacentric chromosomes as well as the number of satellite chromosomes (strains 2 and 3) among five strains. In our study, the chromosome complements of the five strains of *C. esculenta* were different and showed diversity in the karyotypes. Therefore, the karyotypes might be important to identification of strains of Thailand *C. esculenta*.

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## References


Bai, K. V., Magoon, M. L. and Krishnan, R. 1971. Meiosis and pollen mitosis in diploid and triploid *Colocasia antiquorum* Schott. Genetica **42**: 187–198.

Beevi, P. N. 2013. Cyto-palynological studies in taro (*Colocasia esculenta* (L.) Schott.)— An overview. J. Root Crops **39**: 3–9.

Boyce, P. C. and Sookchaloem, D. 2012. Araceae. In: Santisuk, T. and Larsen, K. (eds.). Flora of Thailand Vol. 11 Part 2. Prachachon Co. Ltd., Bangkok. pp. 101–325.

Coates, D. J., Yen, D. E. and Gaffey, P. M. 1988. Chromosome variation in taro, *Colocasia esculenta*. Implications for origin in the Pacific. Cytologia **53**: 551–560.

Gogoi, R. and Borah, S. 2013. Two new species and a new record for *Colocasia* (Araceae: Colocasieae) from Arunachal Pradesh. Northeast India. Gard. Bull. Singapore **65**: 27–37.

Huang, X. F., Ke, W. D., Liu, Y. M., Ye, Y. Y., Li, S. M., Peng, J., Liu, Y. P. and Li, F. 2012. Chromosomal ploidy identification of taro (*Colocasia*) germplasm resources. China Veget. **16**: 42–46.

Huang, S. F., Zhao, Z. F., Chen, Z. Y., Chen, S. J. and Huang, X. X. 1989. Chromosome counts on one hundred species and infraspecific taxa. Acta Bot. Austr. Sin. **5**: 161–176.

Ivancic, A. and Lebot, V. 1999. Botany and genetics of New Caledonian wild taro, *Colocasia esculenta*. Pac. Sci. **53**: 273–285.

Jones, E. J. 1957. Chromosome number and phylogenetic relationships in the Araceae. Ph. D. thesis, University of Virginia, Charlottesville.

Kawahara, T. 1978. Chromosome number of taros in Nepal and India. Chromosome Info. Serv. **24**: 4–5.

Kreike, C. M., Van Eck, H. J. and Lebot, V. 2004. Genetic diversity of taro, *Colocasia esculenta* (L.) Schott, in Southeast Asia and the Pacific. Theor. Appl. Genet. **109**: 761–768.

Kuruvilla, K. M., Dutt, B. and Roy, R. P. 1989. Karyomorphological investigations on aroids of North-Eastern Hills. J. Cytol. Genet. **24**: 13–22.

Levan, A., Fredya, K. and Sandberg, A. A. 1964. Nomenclature for centromeric position on chromosome. Hereditas **52**: 201–220.

Li, H. and Boyce, P. C. 2010. *Colocasia*. In: Wu, Z. Y., Raven, P. H. and Hong, D. Y. (eds.). Flora of China. Vol. 23. Science Press, Beijing and Missouri Botanical Garden Press, St. Louis. pp. 73–75.

Li, R. Q. 1989. Studies on Karyotypes of Vegetables in China. Wuhan University Press, Wuhan.

Marchant, C. J. 1971. Chromosome variation in Araceae II. Richardieae to Colocasieae. Kew Bull. **25**: 47–56.

Okada, H. and Hambali, G. G. 1989. Chromosome behaviors in meiosis of the interspecific hybrids between *Colocasia esculenta* (L.) Schott and *C. gigantea* Hook. f. Cytologia **54**: 389–393.

Parvin, S., Kabir, G., Ud-Deen, M. M. and Sarker, J. K. 2008. Karyotype analysis of seven varieties of taro *Colocasia esculenta* (L.) Schott. from Bangladesh. J. Biol. Sci. **16**: 15–18.

Ramachandran, K. 1978. Cytological studies on South Indian Araceae. Cytologia **43**: 289–303.

Sharma, A. K. and Sarkar, A. K. 1963. Cytological analysis of different cytotypes of *Colocasia antiquorum*. Bull. Bot. Soc. Bengal **17**: 16–22.

Simmonds, N. W. 1954. Chromosome behavior in some tropical plants. Heredity **8**: 139–146.

Sreekumari, M. T. and Mathew, P. M. 1989. Karyomorphology of six cultivars of taro (*Colocasia esculenta* Schott). New Bot. **16**: 127–135.

Sreekumari, M. T. and Mathew, P. M. 1991a. Karyomorphology of five morphotypes of taro, *Colocasia esculenta* (L.) Schott. Cytologia **56**: 215–218.

Sreekumari, M. T. and Mathew, P. M. 1991b. Karyotypically distinct morphotypes of taro, *Colocasia esculenta* (L.) Schott. Cytologia **56**: 399–402.

Stebbins, G. L. 1971. Chromosomal Evolution in Higher Plants. Edward Arnold, London.

Subramanian, D. and Munian, M. 1988. Cytotaxonomical studies in South Indian Araceae. Cytologia **53**: 59–66.

Tanaka, R. 1971. Types of resting nuclei in Orchidaceae. Bot. Mag. **84**: 118–122.

Tanaka, R. 1977. Recent Karyotype Studies. In: Ogawa, K., Kurozumi, K., Koike, S. and Sato, S. (eds.), Plant Cytology. Asakura Shoten, Tokyo. (*in Japanese*)

Tanimoto, T. and Matsumoto, T. 1986. Variations of morphological characters and isozyme patterns in Japanese cultivars of *Colocasia esculenta* Schott and *C. gigantea*. Hook. Jpn. J. Breed. **36**: 100–111.

Yen, D. E. and Wheeler, J. M. 1968. Introduction of taro into the Pacific: the indications of chromosome numbers. Ethnology **7**: 259–267.

Zhang, C. S. 1998. A preliminary study on making plant chromosomal specimens using peppermint oil compound as pretreatment agent. J. Wuhan Bot. Res. **16**: 280–282.

Zhang, G. M. and Yang, Z. H. 1984. Studies on chromosome numbers of main cultivars of *Colocasia esculenta* in China. Acta Hort. Sin. **11**: 187–190.