A NEW SERIES OF STUDIES ON THE FRESHWATER AND LAND PLANARIANS FROM TAIWAN

V. CHROMOSOMES OF DUGESIA JAPONICA JAPONICA
ICHIKAWA ET KAWAKATSU, 1964, FROM FOUR ADDITIONAL LOCALITIES AND DUGESIA SP. FROM LANHSÜ ISLAND

by

SACHIKO TAMURA, IWASHIRO OKI, MASAHARU KAWAKATSU, KUANG YANG LUE, MASAYUKI TAKAI, HIROSHI HORI, AKIRA MUTO, and SYOZO OSAWA

INTRODUCTION

Up to the present, chromosomes of Dugesia japonica japonica ICHIKAWA et KAWAKATSU, 1964, from the following 8 localities in Taiwan have been recorded: Matsutao Island located off Foochow in the Mainland of China, the National Palace Museum and Teinmoo in the suburbs of Taipei, Uulai (also spelled Uulei) and Tsubo in the northern area, Chunghsing-hsintsum in the west-central area, the Kenting National Park in the southernmost area, and Mt. Alishan in the alpine region of the central area (cf. KAWAKATSU, OKI, TAMURA, YAMAYOSHI, LUE & HAGIYA, 1979; TAMURA, OKI, KAWAKATSU, LUE, TAKAI, HORI, MUTO & OSAWA, 1985). Chromosomes of Dugesia sp. (species of Taiwan) from 3 localities in the vicinities of Taipei (Taipei Botanical Garden, Neiwho Pond and Wuku Luchou swamp) have also been reported (cf. KAWAKATSU, OKI, TAMURA, YAMAYOSHI, LUE & HAGIYA, 1979).

In the present paper, chromosomes of D. j. japonica from 4 additional localities (Uulai and Hsiaoi in the northern area, Liukuei in the southwestern area, and Chihsien, near Taitung, in the southeastern area) and those of Dugesia sp., the second unidentified species from Taiwan recorded from Lanhsú Island, off the Eluanwei Cape in the southernmost area, will be reported based upon the 1986 collection. Additionally, a general discussion of the known karyotypes of D. j. japonica from Taiwan will be given, together with some considerations about the karyotypes of the other 2 Dugesia species mentioned above.

1) This study is supported in part by a Grant-in-Aid for Scientific Research from the Ministry of Education, Japan (Nos. 61041039 and 62043032).
2) Preliminary reports of some of the works in this series were presented at the 58th Annual Meeting of the Zoological Society of Japan held in Toyama, on October 7-9, 1987 (TAMURA, OKI, KAWAKATSU, TAKAI, LUE, HORI, MUTO & OSAWA, 1987; KAWAKATSU, OKI, TAMURA, TAKAI, LUE, HORI, MUTO & OSAWA, 1987).
MATERIALS AND METHODS

Localities of the animals used are described in the third report of this series (cf. KAWAKATSU, LUE, TAKAI, HORI, MUTU & OSAWA, 1986, pp. 66-76, Station Nos. 68, 69, 71, 75, and 76, figs. 3-5, pp. 72-73, figs. 7-10). The Uulai and Hsiaoik locations are located in the vicinity of Uulai Hot Spring (cf. KAWAKATSU, LUE, TAKAI, HORI, MUTU & OSAWA, 1985, p. 115, fig. 3).3)

For the purpose of transporting living specimens from the spots to Japan, small thermoses were employed as a container. The water in a thermos was renewed once per day. Animals collected in the subtropical regions of Taiwan survived two week trip by this method.

For the chromosomal analysis, regenerating somatic cells were observed by the use of the techniques described in the previous papers (cf. OKI, TAMURA & KAWAKATSU, 1976; OKI, TAMURA, YAMAYOSHI & KAWAKATSU, 1980, p. 4, fig. 4). Meiotic figures in spermatogenesis of specimens from the Hsiaoik and Liukuei localities were also observed.

OBSERVATIONS

1) Dugesia japonica japonica ICHIKAWA et KAWAKATSU, 1964.

The result of the cytological study of animals from Uulai, Hsiaoik, Liukuei, and Chihpën is shown in Table 1. Photomicrographs of the chromosomes are shown in Figure 1 (A-H). The idiograms are also shown in Figure 2.

Table 1. The chromosome numbers of Dugesia japonica japonica from 4 localities in Taiwan.

<table>
<thead>
<tr>
<th>Localities</th>
<th>No. of specimens examined cytologically</th>
<th>Chromosome nos. &amp; the no. of cells studied in parentheses</th>
<th>Karyotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>Sexual</td>
<td>Asexual</td>
<td></td>
</tr>
<tr>
<td>Uulai</td>
<td>4</td>
<td>1</td>
<td>24+0~1SB (40)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>25 (15)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>25 (83)</td>
</tr>
<tr>
<td>Hsiaoik</td>
<td>5</td>
<td>2</td>
<td>24 (58)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>25 (37)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>25 (51)</td>
</tr>
<tr>
<td>Liukuei</td>
<td>5</td>
<td>3</td>
<td>16 (52)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>24 (120)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>25 (16)</td>
</tr>
<tr>
<td>Chihpën</td>
<td>3</td>
<td>3</td>
<td>24 (133)</td>
</tr>
</tbody>
</table>

Uulai:

Four asexual specimens were examined. Two triploidic aneuploid karyotypes and one triploidic mixokaryotype were found in this population: (3x-1)+1LB+SB=24+0~1SB (Figs. 1C, 2A); (3x-1)+2LB=25 (Fig. 2B); 3x+1LB & (3x-1)+2LB=25 & 25 (Figs. 1E and F, 2C and C').

Hsiaoik:

One sexual and 4 asexual specimens were examined. Two triploidic aneuploid karyotypes and one triploidic mixedaneuploid karyotype were found in this population: (3x-1)+1LB=24 (Fig. 2D); (3x-1)+2LB=25 (Figs. 1D, 2E); (3x-1)+2LB & (3x-1)+3LB=25 & 25 (Figs. 1G and H, 2F and F').

3) The Hsiaoik locality is an upper tributary of the Nanhsishe River near Uulai (alt. 500 m).
Fig. 1. For explanation see on page 59.
Fig. 1. For explanation see on page 59.
Liukuei:

One sexual and 4 asexual specimens were examined. The chromosome number of diploid cells is 2x=16 (Figs. 1 A, 2 G). The orthoploid triploid karyotype and triploid aneuploid karyotype were also found in this population: 3x=24 (Figs. 1 B, 2 H); (3x-1)+2LB=25 (Fig. 2 I).

Fig. 2. Idiograms of *Dugesia japonica japonica* ICHIKAWA et KAWAKATSU from 4 localities in Taiwan. A–C': Uulai. A, (3x-1)+1LB=24; B, (3x-1)+2LB=25; C, 3x+1LB=25; C', (3x-1)+2LB=25. C and C' were found in one body. D–F': Hsiaoii. D, (3x-1)+1LB=25; E, (3x-1)+2LB=25; F, (3x-1)+2LB=25; F', (3x-1-1)+3LB=25. F and F' were found in one body. G–I: Liukuei. G, 2x=16; H, 3x=24; I, (3x-1)+2LB=25. J and J': Chihpêns. J, 3x=24; J', (3x-1)+1LB=24. J and J' were found in one body.

Fig. 1. Photomicrographs of the chromosomes of *Dugesia japonica japonica* ICHIKAWA et KAWAKATSU from 4 localities in Taiwan. A: Liukuei, 2x=16. B: Liukuei, 3x=24. C: Uulai, (3x-1)+1LB=24. D: Hsiaoii, (3x-1)+2LB=25. E and F: Uulai. E, 3x+1LB=25; F, (3x-1)+2LB=25. These 2 figures were found in one body. G and H: Hsiaoii. G, (3x-1)+2LB=25; H, (3x-1-1)+3LB=25. These 2 figures were found in one body.
Chihiben: Three asexual specimens were examined. Only the triploidic mixokaryotype was found in this population: 3x & (3x-1)+1LB=24 (Fig. 2 J and J').

2) Dugesia sp. (species of Lanhsù Island)

Since sexually mature specimens were not obtained from Lanhsù Island, the animal cannot be described now. The result of the cytological study of animals from the Yehyu Valley locality of Lanhsù Island is shown in Table 2. Photomicrographs of the chromosomes are shown in Figure 3 (A-D). In Figure 4, chromosomes found in 2 specimens are shown; they are arranged according to the size of each chromosome.

Five asexual specimens were examined. Four groups of the chromosome numbers (including numbers of SB chromosomes) were found in this population: 19 (Figs. 3 A and B, 4 no. 1); 19 & 21 & 25; 19 & 24 & 25 & 26; 19 & 21 & 24 & 25 & 26 (Figs. 3 C and D, 4 no. 2). The chromosome numbers vary from 19 to 26, and the karyotype of the animal from this population is unidentified yet.

Table 2. The chromosome numbers of Dugesia sp. (species of Lanhsù Island) from Lanhsù Island in Taiwan.

<table>
<thead>
<tr>
<th>Localities</th>
<th>No. of specimens examined cytologically</th>
<th>Chromosome nos.* &amp; the number of cells studied in parentheses</th>
<th>Karyotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Sexual</td>
<td>Asexual</td>
</tr>
<tr>
<td>Lanhsù Island</td>
<td>5</td>
<td>—</td>
<td>2</td>
</tr>
<tr>
<td>(Yehyu Valley)</td>
<td>—</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>—</td>
<td>1</td>
</tr>
</tbody>
</table>

* The chromosome numbers in this table include SB chromosomes.

Fig. 4. Chromosomes of Dugesia sp. (species of Lanhsù Island). The karyotype is unidentified yet. No. 1: Chromosome numbers=19. No. 2: Chromosome numbers=19 & 21 & 24 & 25 & 26. The chromosome numbers in these figures include SB chromosomes.

Fig. 3. Photomicrographs of the chromosomes of Dugesia sp. (species of Lanhsù Island). A, 19; B, 19 (2 sets); C, 21; D, 24. C and D were found in one body.

4) Several sexually mature specimens used for the taxonomic study were obtained from the Liukuei localities.

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KARYOLOGICAL REMARKS ON FRESHWATER PLANARIANS FROM TAIWAN

Dugesia japonica japonica:

We have examined karyologically the animals of Dugesia japonica japonica from 12 localities in Taiwan (cf. KAWAKATSU, OKI, TAMURA, YAMAYOSHI, LUE & HAGIYA, 1979; TAMURA, OKI, KAWAKATSU, LUE, TAKAI, HORI, MUTO & OSAWA, 1985; and the present paper). The diploid karyotype of this subspecies is 2x=16, consisting of 8 pairs of meta- or submetacentric chromosomes in descending order of the size. The known karyotypes of animals from Taiwan classified according to the ploidy and their geographical distribution are as follows (SB chromorones are excluded):

1) Diploid.
   2x. Localities: Matsu-tao Island, Taipei (2 localities), Mt. Alishan, and Liukuei.
2) Triploid.
   3x. Locality: Liukuei.
3) Triploidic Aneuploid. Two karyotypes were found.
   (3x-1)+1LB. Locality: Chungssing-Hsintsum. Varieties of this karyotype with 0 to
   2SB chromosomes were found in Uulai and the Kenting National Park.
   (3x-1)+2LB. Localities: Uulai, Hsiaoi, Tsouho, and Liukuei.
4) Triploidic Mixoaunepend. Four karyotypes were found.
   3x & (3x-1)+1LB. Locality: Chipên.
   3x+1LB & (3x-1)+2LB. Locality: Uulai.
   (3x-1)+1LB & (3x-1)+2LB. Locality: Tsouho.
   (3x-1)+2LB & (3x-1)+3LB. Locality: Hsiaoi.

From the result of the karyological observations on Dugesia japonica japonica summarized above, animals having a diploid karyotype (2x=16) are distributed both in the lowland and alpine regions. Animals having a triploid karyotype (3x=24) are only found in the Liukuei locality now. This karyotype is also found in the central and southern areas of the Japanese Islands, the Southwest Islands of Japan and South Korea (cf. OKI, TAMURA, YAMAYOSHI & KAWAKATSU, 1980, 1981; KAWAKATSU, TAMURA & LUE, 1984; TAMURA, 1986; TAMURA, OKI & KAWAKATSU, In press; see also KAWAKATSU, OKI, TAMURA, SEKIGUCHI & OGREN, 1987).

Animals of Dugesia japonica japonica having triploidic aneuploid karyotypes are rather common in Taiwan and Japan (cf. KAWAKATSU, OKI, TAMURA, YAMAYOSHI, LUE & HAGIYA, 1979; OKI, TAMURA, YAMAYOSHI & KAWAKATSU, 1980, 1981; KAWAKATSU, TAMURA & LUE, 1984; TAMURA, 1986; TAMURA, OKI & KAWAKATSU, In press; see also KAWAKATSU, OKI, TAMURA, SEKIGUCHI & OGREN, 1987).

Animals having triploidic mixoaunepend karyotypes are rather common in Taiwan. This group of karyotypes are also common in the central and southern areas of the Japanese Islands and South Korea (cf. OKI, TAMURA, YAMAYOSHI & KAWAKATSU, 1980, 1981; KAWAKATSU, TAMURA & LUE, 1984; TAMURA, 1984; TAMURA, OKI & KAWAKATSU, In press; see also KAWAKATSU, OKI, TAMURA, SEKIGUCHI & OGREN, 1987).

The orthoploidic mixoploid karyotype (2x & 3x) is rather common in Dugesia japonica japonica of Japan except for the Southwest Islands. In Okinawa Island in the Southwest Islands of Japan, this karyotype is also found in the population of Dugesia japonica ryukyuensis (cf. OKI, TAMURA, YAMAYOSHI & KAWAKATSU, 1980, 1981; TAMURA, OKI & KAWAKATSU, In press; see also KAWAKATSU, OKI, TAMURA, SEKIGUCHI & OGREN, 1987). Why is it that the orthoploidic mixoploid karyotype of 2x & 3x is not found in Taiwan? More light could be thrown on the geographical
distribution of the karyotypes and their evolution by further taxonomic and karyological studies of *Dugesia japonica* distributed widely in the southeastern area of the Far East. Especially, the knowledge in this research field of the species in North Korea and Mainland China should be necessary.

*Dugesia* sp. (species of Taiwan):

We have examined karyologically the animals of *Dugesia* sp. (species of Taiwan) from 3 localities in the vicinities of Taipei. This unidentified species is an inhabitant of swampy places (cf. KAWAKATSU, OKI, TAMURA, YAMAYOSHI, LUE & HAGIYA, 1979). Its chromosome number is 2x=16; the karyotype consists of 7 pairs of meta- or submetacentric chromosomes in descending order of the size and one pair of large subtelocentric chromosomes. Judging from the external characters and the karyotype, there is a high possibility that *Dugesia* sp. (species of Taiwan) should be identical with *Dugesia australasiatica* KAWAKATSU, 1985. This species seems to have been introduced into Japan from some of the Southeast Asiatic countries (cf. KAWAKATSU, TAKAI, OKI, TAMURA & AOYAGI, 1986).

*Dugesia* sp. (species of Lanhsù Island):

The chromosome numbers of this unidentified species from Lanhsù Island are reported in the present paper. Although the karyotypes are not determined yet, chromosomal components of this species are different from those of *Dugesia japonica* and *Dugesia* sp. (species of Taiwan).

**SUMMARY**

*Dugesia japonica japonica* ICHIKAWA et KAWAKATSU, 1964, from 4 additional localities of Taiwan (Ululai, Hsiao, Liukuei, and Chihpên) was studied karyologically. The 8 karyotypes were found (3 of them are new records). They are as follows: 2x=16, 3x=24, (3x-1)+1LB=24, (3x-1)+1LB+SB=24+SB, (3x-1)+2LB=25, 3x & (3x-1)+1LB=24 & 24, 3x+1LB & (3x-1)+2LB=25 & 25, and (3x-1)+2LB & (3x-1-1)+3LB=25 & 25. The mixokaryotypes were found in the animals from the Ululai, Hsiao, and Chihpên localities. Thus, a total of 8 karyotypes of *D. j. japonica* is now recorded in Taiwan (see the section of "Karyological Remarks, etc.").

The karyotypes of *Dugesia* sp. (species of Lanhsù Island) are unidentified yet. The chromosome numbers vary from 19 to 26: 19, 19 & 21 & 25, 19 & 24 & 25 & 26, and 19 & 21 & 24 & 25 & 26.

**REFERENCES**


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中 文 摘 要

臺灣淡水棲和陸棲渦蟲之研究

V. 淡水產渦蟲染色體之研究：新增四個族群 (Dugesia japonica japonica)

和蘭嶼產渦蟲 (Dugesia sp.)

田村幸子・中島藤・川崎正治・呂光洋・高井成幸・堀満・武藤昌・大澤省三

本篇是報導有關臺灣產淡水棲渦蟲 Dugesia japonica japonica ICHIKAWA et KAWAKATSU.
Addresses of the Authors:

Dr. Masaharu KAWAKATSU, Professor of Biology, Biological Laboratory, Fuji Women's College, Kita-16, Nishi-2, Kita-ku, Sapporo (Hokkaido) 001, Japan.

Dr. Masayuki TAKAI, Professor of Biology, Biological Laboratory, Saga Medical School, Nabe-shima-Sanbonsugi, Nabeshima-chô, Saga Prefecture 840-01, Japan.

Dr. Syozo OSAWA, Professor of Biology, Laboratory of Molecular Genetics, Department of Biology, Faculty of Science, Nagoya University, Furô-chô, Chigusa-ku, Nagoya 464, Japan.

Dr. Akira MUTÓ, Associate Professor of Biology; the same address as Dr. OSAWA.

Dr. Hiroshi HORI, Associate Professor of Genetics, Department of Genetics, GEN-IKEN, Hiroshima University, Kasumi, Hiroshima 734, Japan.

Dr. Kuang Yang LUE, Professor of Biology, Ecology Laboratory, Department of Biology, National Taiwan Normal University, No. 88, Section 5, Roosevelt Road, Taipei, Taiwan 11718, Republic of China.

Dr. Iwashiro OKI, Osaka Prefectural Institute of Public Health, Nakamichi-1-chôme 3-69, Higashinari-ku, Osaka 537, Japan.

Dr. Sachiko TAMURA; the same address as Dr. OKI.


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