Chromosomal Studies in the Egyptian Flora
II. Karyotype studies in the genus Plantago L.

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The first reliable chromosome counts in species of the genus Plantago L. was made by McCullagh (1934). Later more detailed cytological investigations were carried out on more than half of the species in this genus. Some of these investigations were made in connection with taxonomic studies in order to elucidate the relationships in particular groups of related species (Bocher et al. 1955, Rahn 1957, Cartier 1971, 1973, Sopova and Rizova 1975, Zemskova 1977). Other studies were concerned with investigating the cytology of Plantago species in certain floras or phytogeographic regions (Gregor 1939, Runemark 1967, Briggs 1973, Favarger and Vasudevan 1972, Fernandes and Franca 1973).

The cytology of the genus Plantago in Egypt has not been a subject of a study. The chromosome number of only three species was reported by Badr (1980). The numbers of some other species which grow in Egypt are also known from chromosome counts in plants from near floras particularly that of Europe. The present study is therefore conducted to investigate the cytological features in species of the genus Plantago from Egypt. This investigation deals not only with chromosome numbers but also with detailed karyotype features such as chromosome length and centromere position. The impact of karyotype features in the taxonomic relationships of the studied species is also elucidated.

Materials and methods

Materials of 12 samples belonging to 10 different species of Plantago were collected from their natural habitats. The studied species and the localities from which they were collected are given in Table 1. The distribution of localities in the country is illustrated in the map (Fig. 1).

Cytological preparations were carried out on root tips obtained from seeds germinated on moist filter paper in petri dishes. Root tips were pretreated with 0.05% colchicine solution for 4 hours and fixed in 3:1 (V/V) ethanol: glacial acetic acid. Squash preparations were made using the Feulgen squash technique and were made permanent by mounting in canada balsam. Cells with good spreading of chromosomes were photographed and prints were enlarged to a magnification of 3000 times. Comparisons of chromosomes of the species studied were made by constructing a karyotype for each species by arranging the chromosomes in homologous pairs in order of their length and arm ratio as measured from the photographic prints. The variation in the chromosome length and arm ratio within the karyotype has been expressed by calculating the standard error (SE) of these parameters.

Results

The cytological features of the 10 investigated species are summarized in Table 1. A description of the karyotypes is given below:

1. *P. albicans* L. (Fig. 1). This species has a chromosome number of $2n=30$. It is
therefore hexaploid with a basic number of $x=5$. The analysis of the karyotype indicates that it is comprised of 2 sets of chromosomes and thus the karyotype may be comprised of three genomes AAB. The two genomes AA are similar containing 20 chromosomes and may be divided into five groups each containing 4 homologous chromosomes, whereas, genome B is composed of 10 chromosomes in 5 homologous pairs. One chromosome pair of this genome (5B) is clearly telocentric and thus the karyotype may be allopolyploid. Several chromosomes are, however more or less similar being metacentric to submetacentric. In addition to the 30 chromosomes comprising the karyotype 3B chromosomes were also recorded in the examined material of \textit{P. albicans}. The chromosome number recorded in this species agrees with a previous count in plants from Egypt (Badr 1980). $2n=20$ was also recorded in this species by Rahn (1957). The $2n=12$ recorded by McCullagh (1934) may be erroneous.

2. \textit{P. crassifolia} Forssk. (Fig. 2). The examined material of this species was found to have a chromosome number of $2n=20$ being tetraploid with $x=5$. The chromosomes of this karyotype may be classified into two sets each containing 10 chromosomes in 5 homologous pairs. Three chromosome pairs in both sets (1, 2 and 3) are similar with regard to length and centromere position. Two other pairs (4 and 5) show slight differences in length and arm ratio. On these basis it may be proposed that this karyotype is allopolyploid. The number recorded here ($2n=20$) agrees with that recorded by Bocher \textit{et al.} (1955) but contradicts the number of $2n=24$ recorded by McCullagh (1934). The later number may be erroneous.

3. \textit{P. crypsoides} Boiss. (Fig. 3). Plants of this species have a diploid chromosome number of $2n=10$ and a basic number of $x=5$. The chromosomes of this karyotype are metacentric to submetacentric with small variation in length and arm ratio. The chromosomes are short with a mean length of $2.55 \pm 0.1 \mu$ and a mean arm ratio of $1.44 \pm 0.12$. The present count ($2n=10$) for \textit{P. crypsoides} coincides with that of Badr (1980). No chromosome counts for this species were reported from other parts of the world.

4. \textit{P. cylindrica} Forssk. (Fig. 4). Plants of this species examined in the present study have a diploid number of $2n=10$ and $x=5$. The mean chromosome length is $3.03 \pm 0.14 \mu$ and the mean arm ratio is $1.44 \pm 0.1$ (Table 1). Like the preceding species there is only small variation in length and centromere position among the chromosomes of the karyotype. No chromosome counts were reported in \textit{P. cylindrica} and thus the karyotype of this species is described here for the first time.

5. \textit{P. arabica} Boiss. (Fig. 5). This species has a chromosome number of $2n=12$ being diploid and thus having a basic number of $x=6$. All chromosomes of the karyotype are more or less metacentric to submetacentric with a mean arm ratio of $1.37 \pm 0.8$. There is, however, a substantial difference in length between the chromosomes of the karyotype. No previous counts have been reported in this species and its karyotype is described here for the first time.

6. \textit{P. lagopus} L. (Fig. 6). Two samples of this species have been studied. One from Burg-El-Arab (sample 1) and the other Madinet Nasr east of Cairo (sample 2). The two samples have a diploid number of $2n=12$ and $x=6$. The chromosomes of both samples are extremely similar in length and centromere position. There is only little variation in length
among the chromosomes of both karyotypes, but some variation in the arm ratio is evident. The two shortest chromosome pairs (5 and 6) are clearly acrocentric, whereas the other four pairs are metacentric to submetacentric. The $2n=12$ recorded in *P. lagopus* here coincides with previous number recorded by McCullagh (1934), Larsen (1960) and Fernandes and Franca (1973). The described karyotype of this species resembles that described by the later authors, but they recorded a nucleolar organizer in one pair of chromosomes.

7. *P. lanceolata* L. (Fig. 7). In this species also a diploid number of $2n=12$ and $x=6
are found. Similar to the previous species there is a small variation in length among the chromosomes of the karyotype, but a recognizable difference in arm ratio was found. The two shortest chromosome pairs are acrocentric while the other four pairs are metacentric to submetacentric. A number of chromosome counts in *P. lanceolata* have been reported from various parts of the world. The most recent are those of Favarger and Vasudevan (1972), Fernandes and Franca (1973), Sopova and Rizova (1975) and Zemskova (1977). All these authors recorded 2n=12 in plants of this species. A tetraploid number of 2n=24 was recorded by McCullagh (1934). In the karyotype of this species described by Favarger and Vasudevan (1972), Fernandes and Franca (1973) and Zemskova (1977), one pair of nucleolar chromosomes was recorded.

8. *P. major* (Fig. 8). This species has a diploid number of 2n=12 and x=6. The karyotype of this species shows little variation in length but exhibits a substantial difference in arm ratio among the chromosomes. One pair of chromosomes (1) is metacentric, 3 pairs (2, 3 and 4) are submetacentric, while the other two pairs (5 and 6) are acrocentric. A diploid number of 2n=12 was also recorded in *P. major* by several other authors (e.g. Runemark 1967, Fernandes and Franca 1973, Briggs 1973, Zemskova 1977, Jain 1978). The karyotype described here resembles that described by some authors (e.g. Briggs 1973, Jain 1978). Favarger and Vasudevan recorded a hexaploid number of 2n=36 in plants of this species from the Himalaya.

9. *P. notata* Lag. (Fig. 9). A diploid chromosome number of 2n=12 is recorded in this species. Four chromosome pairs in the karyotype are more or less metacentric to submetacentric, whereas two chromosome pairs (5 and 6) are acrocentric. No previous counts are reported in this species and its karyotype is described here for the first time.

10. *P. ovata* Forssk. Two samples of this species have been investigated. One sample was collected from Sallum (sample 1) and the other from Cairo Suiz road. Sample 1 is diploid with 2n=8, whereas sample 2 has a tetraploid number (2n=16). Thus the basic number of this species is x=4. The karyotype of sample 1 (Fig. 10) is comprised of two pairs of metacentric to submetacentric chromosomes and two pairs of acrocentric chromosomes. The karyotype of sample 2, on the other hand (Fig. 11) may be divided into 2 sets of chromosomes each

<table>
<thead>
<tr>
<th>Species</th>
<th>Locality</th>
<th>2n</th>
<th>x</th>
<th>Mean chromosome Length ± SE</th>
<th>Mean arm ratio ± SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <em>P. albicans</em></td>
<td>Sinai, 25 km East Al-Arish</td>
<td>30+3B</td>
<td>5</td>
<td>3.62 ± 0.08</td>
<td>1.45 ± 0.03</td>
</tr>
<tr>
<td>2. <em>P. crassifolia</em></td>
<td>25 km West Alexandria</td>
<td>20</td>
<td>5</td>
<td>2.90 ± 0.15</td>
<td>1.60 ± 0.11</td>
</tr>
<tr>
<td>3. <em>P. crypsoides</em></td>
<td>Burg El-Arab, 50 km West Alex.</td>
<td>10</td>
<td>5</td>
<td>2.55 ± 0.10</td>
<td>1.40 ± 0.12</td>
</tr>
<tr>
<td>4. <em>P. cylindrica</em></td>
<td>Sinai, Sdr, 80 km South Suiz</td>
<td>10</td>
<td>5</td>
<td>3.03 ± 0.14</td>
<td>1.44 ± 0.10</td>
</tr>
<tr>
<td>5. <em>P. arabica</em></td>
<td>Sinai, East Al-Arish</td>
<td>12</td>
<td>6</td>
<td>4.26 ± 0.25</td>
<td>1.37 ± 0.08</td>
</tr>
<tr>
<td>6. <em>P. lagopus 1</em></td>
<td>Burg El-Arab</td>
<td>12</td>
<td>6</td>
<td>2.40 ± 0.17</td>
<td>1.86 ± 0.37</td>
</tr>
<tr>
<td>7. <em>P. lagopus 2</em></td>
<td>Madinet Nasr, East Cairo</td>
<td>12</td>
<td>6</td>
<td>2.62 ± 0.17</td>
<td>1.82 ± 0.36</td>
</tr>
<tr>
<td>8. <em>P. lanceolata</em></td>
<td>25 km South Alex.</td>
<td>12</td>
<td>6</td>
<td>2.96 ± 0.15</td>
<td>1.78 ± 0.40</td>
</tr>
<tr>
<td>9. <em>P. major</em></td>
<td>Kafr El-Sheikh, Nile Delta</td>
<td>12</td>
<td>6</td>
<td>2.04 ± 0.12</td>
<td>1.38 ± 0.12</td>
</tr>
<tr>
<td>10. <em>P. notata</em></td>
<td>Sinai, 25 km East Al-Arish</td>
<td>12</td>
<td>6</td>
<td>4.01 ± 0.22</td>
<td>1.50 ± 0.13</td>
</tr>
<tr>
<td>11. <em>P. ovata 1</em></td>
<td>Sallum, 450 km West Alex.</td>
<td>8</td>
<td>4</td>
<td>3.04 ± 0.15</td>
<td>1.88 ± 0.30</td>
</tr>
<tr>
<td>12. <em>P. ovata 2</em></td>
<td>Cairo-Suiz Rd., 50 km East Cairo</td>
<td>16</td>
<td>4</td>
<td>3.22 ± 0.20</td>
<td>2.05 ± 0.20</td>
</tr>
</tbody>
</table>

2n=Somatic chromosome number
x=Basic chromosome number.

containing 4 pairs of chromosomes. There is a gradual reduction in length and arm ratio in both sets. Two chromosome pairs (1 and 2) in each set are more or less metacentric to submetacentric. The two pairs 3 and 4 of set A are acrocentric. The pair 3 of set B is also acrocentric, whereas pair 4 of this set (4B) is comprised of two telocentric chromosomes. The two sets of this karyotype therefore may be designated as two separate genomes and this sample may be allopolyploid. The diploid number of 2n=8 recorded in sample 1 agrees with a number of counts for this species (McCullagh 1934, Rahn 1966, Stebbins and Day 1967). No polyploid counts were recorded from other parts of the world, but Badr (1980) found 2n=16 in plants from Egypt.

Discussion

The karyotype analysis of the studied species shows that P. arabica and P. notata have the longest chromosomes, whereas P. crypsoides, P. lagopus and P. major have the shortest chromosomes. The two former species showed the most evident variation in length among the chromosomes of the karyotype, while the karyotype of P. crypsoides exhibited the least variation in length. P. arabica, P. albicans, P. crassifolia and P. cylindrica showed small variation among chromosomes regarding centromere position. In this respect P. lagopus and P. lanceolata have the most asymmetric karyotypes.

Of the 10 species studied a basic chromosome number of x=5 was revealed in 4 species. These are P. albicans, P. cylindrica, P. crassifolia and P. crypsoides. The two former species share a number of morphological similarities and are placed together in section Albicans Barn. of subgenus Psyllium (Juss.) Harms & Reiche and also in series Albicantes by Rahn (1978). The grouping of these two species is supported by their cytological characteristics. P. crassifolia, on the other hand, is placed in subgenus Coronopus Rahn, section Coronopus Lam & D.C. which is characterized by having a basic number of x=5. The karyotype features of this species support its taxonomic position. P. crypsoides resembles P. coronopus of the same section in having penatifid leaves, hairy bracts and short spikes. The sectional assignment of P. crypsoides, however, needs further investigations.

Five of the studied species were found to have a basic number of x=6. Species with this number are P. arabica, P. lagopus, P. lanceolata, P. major and P. notata. P. arabica and P. notata are cytologically investigated for the first time here and are found to contain the longest chromosomes of the studied species. P. arabica is morphologically distinct from the other Egyptian Plantago species by being a shrublet with a distinct stem. P. notata, on the other hand, resembles P. crypsoides and P. coronopus in having penatifid leaves but is characterized by its woody spikes and the presence of brown spots on the throat of a long ciliate corolla.

The karyotypes of P. lagopus and P. lanceolata are similar. The two species also share several morphological similarities. P. lanceolata is placed in section Lanceifolia Barn of subgenus Psyllium by Rahn (1978). In view of the cytological and morphological similarities between these two species P. lagopus may also be placed in section Lanceifolia.

The fifth investigated species with x=6 is P. major which is characterized by short chromosomes and a somewhat symmetric karyotype. Morphologically P. major is also distinct by its 3–9 veined broad ovate glabrous leaves, narrow green spikes and its affinity to grow in moist places. Taxonomically both Pilger (1937) and Rahn (1978) placed this species in subgenus Plantago which comprises species with x=6. The cytological and morphological characteristics of P. major are compatible with its taxonomic position. Sectional delimitation of subgenus Plantago, however, is yet to be made.

P. ovata is the only species with x=4 encountered in this study. In fact a basic number of x=4 is so far recorded in two species of the genus. P. ovata shows a number of morphologi-
cal similarities with *P. albicans* and *P. cylindrica* particularly in having densely pubescent to villous scapes and elliptic bracts. *P. ovata* is taxonomically placed together with these two species in section *Albicans* of subgenus *Psyllium*. *P. ovata*, however, is separated in series *Ovatae* which is characterized by a basic chromosome number of $x=4$ as recorded in *P. ovata*.

### Summary

The cytological features including chromosome counts and karyotype features have been investigated in 10 species of the genus *Plantago* from Egypt. A basic number of $x=5$ was recorded in *P. albicans*, *P. crassifolia*, *P. cryposides* and *P. cylindrica*, whereas $x=6$ was recorded in *P. arabica*, *P. lagopus*, *P. lanceolata*, *P. major* and *P. notata*. *P. ovata* is the only species in which $x=4$ was revealed. The chromosome counts of *P. cylindrica*, *P. arabica* and *P. notata* are reported here for the first time, while polyploid numbers are recorded in *P. albicans*, *P. crassifolia* and *P. ovata*. Polyploidy was not encountered in the species with $x=6$. The karyotypes of all species were described and compared. Moreover the impact of the cytological features on the taxonomic treatments and the relationships of the studied species have been discussed.

### References


