CONTRIBUTION TO THE CYTOTAXONOMY OF SOME CRUCIFERAE FROM IRAN

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Chromosome numbers are given for 30 species of *Cruciferae* belonging to 27 genera from Iran. *Aethionema trinervium* var. *apterocarpum* (2n=14), *Anastatica hierochuntica* (2n=22), *Boreava orientalis* (2n=14), *Brossardia papyracea* (2n=28), *Buchingera axillaris* (2n=16), *Citharelοma lehmanii* (2n=26), *Clastopus erubescens* (2n=16), *Cryptospora falcata* (2n=14), *Didymophysa aucheri* (2n=14), *Eremobium aegyptiacum* (2n=16), *Farsetia heliophila* (2n=24), *Fortuynia bungei* (2n=32), *Graellsia stylosa* (2n=14), *Hesperis persica* (2n=12), *Isatis koeie* (2n=14), *I. kotschyana* (2n=28), *I. leuconeura* (2n=14), *Lachnoloma lehmanii* (2n=14), *Lepidium cartilagineum* (2n=16), *Matthiola alyssifolia* (2n=14), *M. afghanica* (2n=12), *Micrantha multicaulis* (2n=14), *Moricandia sinaica* (2n=28), *Octoceras lehmannianum* (2n=14). *Peltaria angustifolia* (2n=14), *Physorrhynchus chamaerapistrum* (2n=32), *Spirrorhynchus sabulosus* (2n=14), *Srtoganowia affghana* (2n=16), *Tetracme quadricornis* (2n=14), *Zerdana anchonioides* (2n=14). Of these, the chromosome numbers of 25 species and 11 genera were unknown previously-Based on chromosomal and morphological characters, some taxonomic relationships are suggested for these taxa.

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بررسی سیتوتاگزونومی برخی گونه‌های تیره شب‌بو از ایران

احمدرضا خسروی و علی اصغر معصومی

اعداد کروموزومی برای ۳۰ گونه از ۲۷ جنس خانواده شب‌بو در ایران ارائه شده است. از این تعداد، عدد کروموزومی ۲۵ گونه و ۱۱ جنس قبلاً نامعلوم بوده است. براساس خصوصیات کروموزومی و مورفولوژیکی برای تعدادی از تاکسونها روابط خویشاوندی تاکسونومیکی پیشنهاد شده است.

INTRODUCTION

Using chromosome number in *Cruciferae* is a useful criterion in taxonomical evaluations. The advantages of this method are twofolds. One, in some cases a consistency of chromosome number within genera coupled with morphological differences between related genera are helpful in determining where generic lines of demarcation are rightfully drawn (Rollins 1966), and two, in other instances related genera are recognized by the same basic chromosome number coupled with morphological characters.

Although several important studies have been done on the cytotaxonomy of *Cruciferae* from Iran (Aryavand 1975 a, b, 1976, 1978, and 1983; Ghaffari 1985, 1986a, b, 1987a, b, c, and 1988; Maassoumi 1980), there are still many genera and species that have not been studied. In the present work, 30 species belonging to 27 genera were investigated with respect to their chromosome numbers and their relative sizes.

In this study an attempt is made to find some correlations between cytological and morphological chracters, and taxonomic judgements are based on these correlations and also on viewpoints provided by other taxonomists.

MATERIALS AND METHODS

Chromosome counts were based on preparation of root tips grown from seeds collected either from natural habitats or from herbarium sheets supplied by the Research Institute of Forests and Rangelands herbarium (TARI). Root tips were fixed in ethanol/acetic acid (3: 1), stained and squashed in acetocarmine. A complete list of 30 species of *Cruciferae* which were karyotyped is given in table 1.

RESULTS AND DISCUSSION

1. Aethionema trinervium (DC.) Boiss. var. **apterocarpum** (Rech. f. & Aell.) Hedge; 2n=14 (Fig. 1).

The chromosome number reported for *Aethionema trinervium* (DC.) Boiss. is 2n=42 (Ghaffari 1988). Based on fruit morphology and persistent sepals, this variety seems to be different from *A. trinervium* and has been introduced as *Aethionema apetrocarpum* Rech. f. & Aell. (Rechinger 1951). The chromosomal difference between these two taxa along

Talbe 1. List of materials used in chromosome studies.

Taxon	Locality
Anastatica hierochuntica L.	Bandar-Abbas: 119 km from Minab to Jask, 20 m; Mozaffarian 45086.
Aethionema trinervum (DC.) Boiss. var. *apterocarpum* (Rech. f. & Aell.) Hedge	Khorasan: N. of Esferayen, road from Assadli to Polkotal, 2000 m, Mozaffarian 48736.
Boreava oreintalis Jaub. & Spach.	Chaharmahal-e-Bakhtiari: Brojen, 2200 m, Mozaffarian.
Brossardia papyraceae Boiss.	Hamadan: Lalejin to Taherlu, Jamshidabad and Gonbadan, 1900 m, Mozaffarian 64586.
Buchingera axillaris Boiss.	Damavand: 1700 m, Mozaffarian.
Cithareloma lehmannii Bge.	Esfahan: Kashan, Mardabad, Khosravi.
Clastopus erubescens Hausskn.	Hamadan: Mozaffarian.
Cryptospora falcata Kar. & Kir.	Khorasan: Sarakhs-Torbat-e Jam area, 31 km on road from Salehabad to Torbat-e Jam, 100 m, Mozaffarian 23474.
Didymophysa aucheri Boiss.	Chaharmahal-e Bakhtiari: Zard kuh-opposite to Tunel-e Kuhrang, 2600-3200 m, Mozaffarian 57681.
Eremobium aegypticum (Spreng.) Hoch.	Baluchestan: Bampur, 1500 m, Mozaffarian 23051.
Farsetia heliophila Bge. ex Cosson	Bandar Abbas: 6 km from B. Khamir to B. Lengeh, 50 m, Mozaffarian 4349.
Fortuynia bungei Boiss.	Bandar Abbas: 400-700 m, Mozaffaran 49812.
Graellsia stylosa Boiss. & Hohnen.	Tehran: Shemiran, 2000 m, Mozaffarian 43728.
Hesperis persica Boiss.	Esfahan: Kashan, Ghamsar, Kuh-e Ghebleh, 1900 m, Mozaffarian 42120.
Isatis koeiei Rech. f.	Kohgiluyeh & Boirahmad: 42 km to Dogonbadan, 800 m, Mozaffarian 38493.
Isatis kotschyana Boiss. & Hohen.	Tehran: Firuzkuh, Lazou, Kariz, 2500 m, Mozaffarian 54175.
Isatis leuconeura Boiss. & Buhse	Khorassan: Esferayen: Shah Jahan MTS. Noushirvan village, 1900 m, Mozaffarian 48641.
Lachnoloma lehmanni Bge.	Tehran: Ca. 15 km from Eivaneky to Garmsar, 1000 m, Mozaffarian 58843.
Lepidium cartilagineum (J. Mayer) Thell.	Arak: S. of Kavire-Meyghan, Akhani, 966.
Matthiola alyssifolia (DC.) Bornm.	Chaharmahal-e Baktiari: Pirkuh, 2400 m, Mozaffarian 62123.

Table 1. cont.

Matthiola afghanica Rech. f. & Koeie	Semnan: Ca 35 km from Semnan on road to Damghan, Mozaffarian 29456.
Micrantha muticaulis (Boiss.) Dvorak	Chahrmahal-e-Bakthiari: Brojen to Dorahan, 2300-2700 m; Mozaffarian 57208.
Moricandia sinaica (Boiss.) Boiss.	Bandar-Abbas: 110 km from B. A to Sirjan, 1100, Mozaffarian 57208.
Octoceras lehmanianum Bge.	Semnan: Sorkh-e Dehaghin, 1250 m, Mozaffarian 58846.
Peltaria angustifolia DC.	Esfahan: Semirom to Padena, Tang-e Shahid, 2000 m, Mozaffarian 2840.
Physorrhynchus chamaerapistrum (Boiss.) Boiss.	Khuzistan: 20 km from Masjed Soleman to Shushtar, 100 m, Mozaffarian 39041.
Spirorrhynchus sabulosus Kar. & Kir.	Semnan: Touran protected area, 1250 m, Mozaffarian 29097.
Stroganowia affghana (Boiss.) Pavlov.	Khorasan: Dare-gaz: Park-e Tandureh, 950 m, Khosravi.
Tetracme quadricornis (Steph. in Willd). Bge.	Semnan: Sorkh-e Dahaghine, 1250 m, Mozaffarian 48842.
Zerdana anchonioides Boiss.	Esfahan: N. side of Kuh-e Dena, 3500-4000 m, Mozaffarian 46171.

with differences in morphological characters indicate that probably they are two distinct species. It is to be noted that, the species of *Aethinema* with x = 7 had previously been placed in the genus *Eunomia*. Other species of *Aethionema* have x = 6. Based on cytological evidence, Monton (1932) had proposed separation of *Eunomia* from *Aethionema*. The presence of crescent shaped lateral glands in *Aethionema* with x=7 and the presence of minute, semiglobose glands in species with x=6 are evidence in support of this suggestion. In addition to that, with respect to the shape of the lateral glands (crescent shape) and also considering the basic chromosome number (x=7), it is more reasonable to propose that the species of *Aethionema* with x=7 are more likely related to *Thlaspi* than to *Aethionema* with x=6. Based on this investigation and morphological characters, Mozaffarian (1996) recently made two new combinations, i.e *Thlaspi apterocarpum*

(Rech. f. & Aellen) Mozaffarian and *T. trinervium* (DC.) Mozaffarian.

2. Anastatica hierochuntica L.; 2n=22.

This chromosome number is confirmed by several previous counts. The chromosomes were small in size. Schulz (1936) placed this genus in the tribe *Euclideae*. The chromosome number (2n=22) together with morphological characters such as two lateral appendages in the upper part of the fruit, and the presence of stellate hairs suggest that *Anastatica* is closely related to *Diceratella, Morettia, Notoceras* and *Parollinia*, which have been placed in tribe *Matthioleae* by Schulz (1936) and in tribe *Hesperideae* by Janchen (1942).

3. Boreava orientalis Jaub. & Spach; 2n=14 (Fig. 2).

Mozaffarian (1985), recorded this species from Iran. The previous chromosome count for *Boreava aptera* Boiss. & Helder. was 2n=14 (Carrique & Matinez 1984). Chromosomes were small in size. *Boreava*, like *Chartoloma, Horwoodia, Isatis, Pachyptergium, Sameraria, Schimpera, Spirorrhynchus* and *Texiera* are nucamentoid comprising of one-seeded indehiscent fruit; lateral and median glands are present and form a closed ring around the base of the filaments. Exclusively *Horwoodia* has 2n=26 (probably x=13) while other genera have x=7 and their chromosomes are small. The incidence of x=13 may be a secondary basic number which has been derived from x=14 through dysploidy.

4. Brossardia papyraceae Boiss.; 2n=28 (Fig. 3).

This chromosome number (2n=28) agrees with what has been reported by Kuffer (1980). The chromosomes were small. Both presence of crescent shaped lateral nectar glands and also x=7 indicate a close relationship between *Brossardia* and *Thlaspi.*

5. Buchingera axillaris Boiss.; 2n=16 (Fig. 4).

This is the first report of chromosome count in *Buchingera*. Chromosomes were of medium size. Schulz (1936) has placed this genus in tribe *Alysseae*. Exclusively, *Farsetia* has a count of x=6, while other genera of *Alysseae* described by Schulz have x= 8 (and very rarely x=7 and 11) with densely stellate hair and four small lateral glands. These show that *Alysseae* wihtout *Farsetia* may be a natural group.

6. Cithareloma lehmannii Bge.; 2n=26 (Fig. 5).

This is the first report of a chromosome count in *Cithareloma*. The chromosomes were small. The genus *Cithareloma* seems to be closely related to *Eremobium* in which 2n=26 was reported in *E. aegypticum* (Rodman 1978).

7. Clastopus erubescens Hausskn.; 2n=16 (Fig. 6).

This is the first chromosome number report for this taxon. This chromosome count was also reported for *Clastopus vestitus* (Massoumi 1980). The chromosomes were of medium size. The chromosome number corresponds with other genera of the tribe *Alysseae* described by Schulz (1936).

8. Cryptospora falcata Kar. & Kir.; 2n=14 (Fig. 7).

This is the first report of a chromosome count in this genus. The chromosomes were of medium size. Based on chromosome size and number this genus is to be placed in tribe *Hesperideae.*

9. Didymophysa aucheri Boiss.; 2n=14 (Fig. 8).

The chromosome number 2n=14, is different from what was reported by Nazarova (1984) as 2n=16. The chromosomes were small. THe presence of crescent shaped lateral nectar glands and probably x=7 suggest that this genus is related to *Thalspi.* Janchen (1942) placed *Didymophya* with *Coluteocarpus* in tribe *Lepidieae*, and subtribe *Physarrinae* and Hayek (1911) placed it in subtribe *Thlaspi* along with *Eunomia* and *Thalspi. Coluteocarpus vesicaria* has a number of 2n=14 (Monton 1932) and similar to *Didymophya, Coluteocarpus* has crescent shaped lateral nectar glands which are also present in *Thalaspi, Eunomia* and other related genera with x=7.

10. Eremobium aegyptiacum(Spreng.) Hochrcutiner; 2n=16 (Fig. 9).

The present chromosome count of 2n=16 does not agree with previous counts of 2n=20 (Podlech 1986) and 2n=26 (Rodman 1978). The chromosome size in our specimen was large while previously they have been reported to be small. Large and medium chromosomes are found in *Hesperideae* (including *Matthioleae*) and *Alysseae* of Schulz (1936).

11. Farsetia heliophila Bge. ex Cosson.; 2n=24 (Fig. 10).

This is the first chromosome number

report for this taxon. The chromosome count of 2n=24 agrees with previous chromosome counts in this genus. Previous counts in *Farsetia* (2n=12, 24, 60 and 72) strongly indicate x=6 is the base number for the genus. x=6 does not correspond with other genera of the tribe *Alysseae* of Schulz (x=8). Zohary (1966) placed this genus in *Arabideae,* however different morphological characters appraoch this genus to different genera; bipartie appressed white hairs (*Erysimum*); erect sepales, long clawed petals, horseshoe shaped lateral glands (*Eremobium* and *Cithareloma*). Bipartite and deccurent stigma and long fruit show that the position of *Farsetia* is in tribe *Matthioleae* of Schulz or more properly *Hesperideae* of Janchen (1942). The basic number, x=6. is common in tribe *Hesperideae*, while in *Alysseae* and *Arabideae*, x=8.

12. Fortuynia bungei Boiss.; 2n=32 (Fig. 11).

This is the first report for this genus from Iran. The size of chromosomes were small. Schulz (1936) placed *Fortuynia* along with *Physorrhynchus* and *Zilla* in subtribe *Zillineae*. The chromosome number of *Fortuynia* corresponds with the two other genera and showed that *Zillineae* is a natural group.

13. Graellsia stylosa Boiss & Hohen.; 2n=14 (Fig. 12).

This is the first report of a chromosome count in this species. The chromosome number agrees with previous counts reported for this genus (Ghaffari 1988b). The size of the chromosomes was small. Based on fruit morphology Schulz (1936) placed this genus along with *Draba, Erophila, Petrocallis* in tribe Drabeae. Morphological chracters like the presence of lateral and median nectar glands that form a closed ring around the base of the filaments, undulate epidermal cells of the septum and also a garlic smell along with x=7 relates this genus to *Peltaria* in tribe *Lunarieae.*

14. Hesperis persica Boiss., 2n=12 (Fig. 13)

This is the first chromosomes number report for this taxon. The size of the chromosomes were so large, and similar to other species of this genus.

15. Isatis koeiei Rech. f.; 2n=14 (Fig. 14)

This is the first report of a chromosome

count in this species which is in accordance with previous count reported for this genus. The size of the chromosomes was small.

16. Isatis kotschyana Boiss. & Hohen.; 2n=28 (Fig. 15).

This is the first chromosome number report for this taxon. Chromosomes were small in size. Considering x=7 as the basic chromosome number for *Isatis,* then the presence of 2n=28 indicates that this species is tetraploid.

17. Isatis leuconeura Boiss. & Buhse; 2n=14 (Fig. 16).

This is the first report of a chromosome count in this species. The size of the chromosomes were small.

18. Lachnoloma lehmannii Bge.; 2n=14 (Fig. 17).

This chromosome number is reported for this monotypic genus for the first time. The chromosomes were large. According to Janchen's system (l. c.) *Lachnoloma* was placed in *Hesperideae*. The chromosome number and size support this contention.

19. Lepidium cartilagineum (J. Meyer) Thell; 2n=16 (Fig. 18).

This chromosome number is different from the previously count, 2n=40 (Monton 1932). The size of the chromosomes were small.

20. Matthiola alyssifolia (DC.) Bornm.; 2n=14 (Fig. 19).

This is the first chromosome number report for this taxon. Like other species of *Matthiola*, the chromosomes were very large. In tribe *Hesperideae* of Janchen (1942), only *Hesperis* and *Matthiola* have very large chromosmes. Monton (1932) as indicated that these two genera are very closely related.

21. Matthiola afghanica Rech. f. & Koeie; 2n=12 (Fig. 20).

This is the first chromosomes number report for this taxon. The chromosomes were very large.

22. Micrantha multicaulis (Boiss.) Dovorak, 2n=14 (Fig. 21).

This is the first report of chromosome count in this monotypic genus. The chromosome size was medium. The position of *Micrantha* in the tribe *Hesperideae* is well supported by both the number and size of the chromosomes.

23. Moricandia sinaica (Boiss.) Boiss.; 2n=28 (Fig. 22).

This is the first report on chromosome

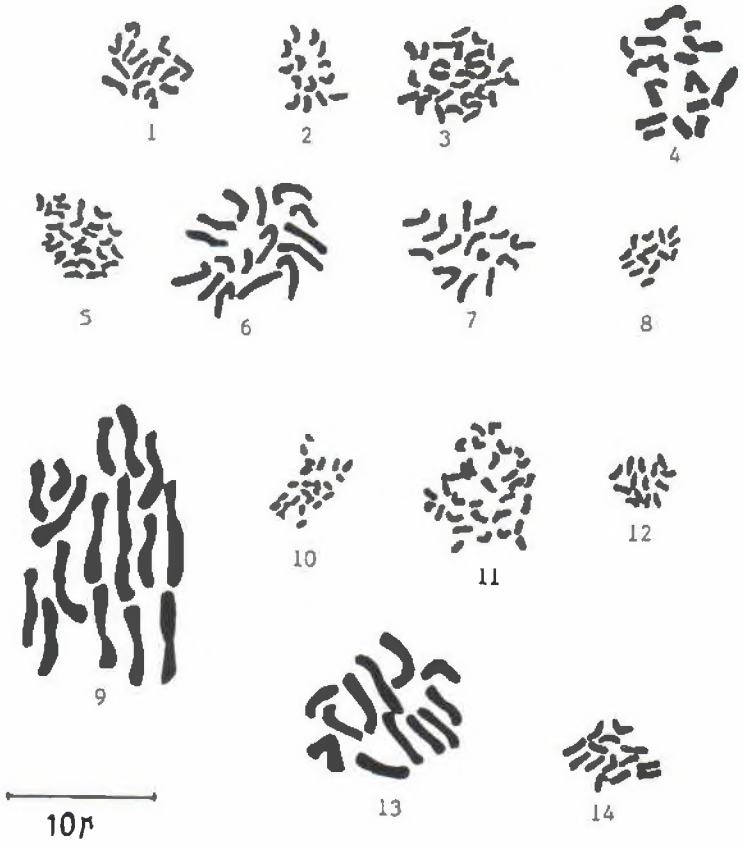

Fig. 1-14 Chromosomes of some *Cruciferae* species in mitosis. 1. *Aethionema trinervium* var. *aptercarpum* (2n=14). 2: *Boreava orientalis* (2n=14). 3: *Brossardia papyraceae* (2n=28). 4: *Buchingera axillaris* (2n=16). 5: *Cithareloma lehmanii* (2n=26). 6: *Clastopus erubescens* (2n=16). 7: *Cryptospora falcata* (2n=14). 8: *Didymophysa aucheri* (2n=14). 9: *Eremobium aegyptiacum* (2n=16). 10: *Farsetia heliophila* (2n=24). 11: *Fortuynia bungei* (2n=32). 12: *Graellsia stylosa* (2n=14). 13: *Hesperis persica* (2n=12). 14: *Isatis koeiei* (2n=14).

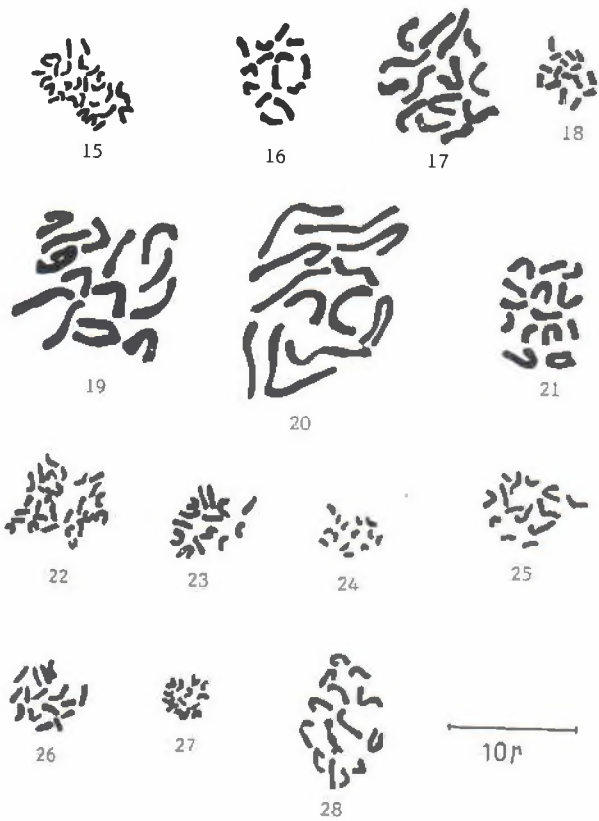

Fig. 15-28: Chromosomes of some *Cruciferae* species in mitosis. 15: *Isatis kotschyana* (2n=28). 16: I. *leuconeura* (2n=14). 17: *Lachnoloma lehmanii* (2n=14). 18: *Lepidium cartilagineum* (2n=16). 19: *Matthiola alyssifolia* (2n=14). 20 *M. afghanica* (2n=12). 21: *Micrantha multicaulis* (2n=14). 22: *Moricandia sinaica* (2n=28). 23: *Octoceras lehmannianum* (2n=14). 24: *Peltaria angustifolia* (2n=14), 25: *Spirrorhynchus sabulosus* (2n=14), 26: *Stroganowia affghana* (2n=16). 27: *Tetracme quqdricornis* (2n=14). 28: *Zerdana anchchonioides* (2n=14).

number in this species. The chromosomes were small. This is in accordance with several previous reports for this genus.

24. Octoceras lehmannianum Bge.; 2n=14 (Fig. 23).

This chromosome number is reported for the first time in this genus. The chromosome size was small. Both the chromosome number and size indicate that this genus is to be placed in subtribe *Euclidinae*, tribe *Hesperideae* (Janchen, 1942). All genera of *Euclidinae* have 2-celled nucamentaceous fruit with x=7.

25. Peltaria angustifolia.; 2n=14 (Fig. 24).

This is the first chromosmes number report for this taxon. This confirms the previous report for this genus. The chromosomes were small in size.

26. Physorrhynchus chamaerapistrum (Boiss.) Boiss.; 2n=32.

This is the first report of a chromosome number in this species. In *Physorrhynchus brahuicus* Hook., the chromosome number has been reported to be 2n=32 (Baquar 1969) which agrees with the number that we have found.

27. Spirorrhynchus sabulosus Kar. & Kir.; 2n=14 (Fig. 25).

This is the first report on chromosome number in this monotypic genus. The chromosomes were small. Like *Isatis* and related genera, the fruit is a one seeded indehiscent nucamentoid, lateral and median glands form a ring around the base of the filaments. According to Janchen's system (Janchen 1942), this genus is placed in *Sisymbrieae.*

28. Stroganowia affghana (Boiss.) Pavlov; 2n=16 (Fig. 26).

This is the first report on chromosome number in the genus *Stroganowia.* The chromosomes were small. Like *Lepidium,* the genera *Hymnenophysa, Coronopus, Cardaria* and *Biscutella* all have x=8. In tribe *Lepidieae* all these genera have lateral and median nectar glands and Hayek (1911) has placed them in subtribe *Lepidiinae. Lepidiinae* may be a natural group in tribe *Lepidieae.*

29. Tetracme quadricornis (Steph. in Willd.) Bge.; 2n=14 (Fig. 27).

This is the first report on chromosome number in the genus *Tetracme.* Chromosomes were small in size.

Chromosome number, fruit and nectar gland morphology correlates, *Tetracme* with *Octoceras.*

30. Zerdana anchonoides Boiss.; 2n=14 (Fig. 28)

This is the first report on chromosome number in this monotypic genus. Chromosomes were medium in size. Based on morphological characters, *Zerdana* is closely related to *Sterigmostemum* and *Anchonium* (Jacquemound 1985). Like *Zerdana* these two genera have medium sized chromosomes (Aryavand 1975a, and Maassoumi 1980) and x=7.

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REFERENCES

Aryavand, A. 1975a: Contribution a l'etude cytotaxonomique de quelques Cruciferes de l'Iran et de la Turquie. -Bull. Soc. Neuchateoise. Sci. Nat. 98: 43-58.

- 1975b: Contribution a l'etude cytotaxonomique de quelques Angiospermes de l'Iran. -Bot. Notiser. 128: 299-311.

- 1976: In Love, A. IOPB chromosome number reports. LII. -Taxon 25: 345-346.

- 1978: Contribution a l'etude cytotaxonomique de Cruciferae de l'Iran II. -Bull. Soc.l Neuchatel. 101: 95-106.

- 1983: Contribution a l'etude cytotaxonomique de Cruciferae de l'Iran III. -Bull. Soc. Neuchatel. 106: 123-130.

Baquar, S. R. 1969: To new generic chromosome records of Pakistan. -J. Sci. Ind. Res. 12: 164-165.

Carrique, M. C. & A. J. Matinez, 1984: Numeros de coromosomas de Cruciferae 1. -Paradiana 3: 113-128.

Ghaffari, S. M. 1985: Chromosome number reports LXXXVIII-Taxon. 34 (3): 547-551.

- 1986 a: Chromosome number reports XCI. -Taxon. 35 (2): 404-410.

- 1986 b: Chromosome number reports XCIII. -Taxon 35 (4): 897-903.

- 1987 a: Chromosome studies in some flowering plants of Iran. -Rev. Cytol. Biol. Veget - Bot. 10: 3-8.

- 1987 b: Chromosome number reports XCV. -Taxon. 36 (2): 493-498.
- 1987 c: Chromosome number reports XCVI. -Taxon. 36 (3): 659-661.
- 1988 a: Etudes chromosomiques de quelques phaneragames d'l Iran, II. -Bull. Sco. Neuchatel III: 91-94.
- 1988 b: Chromosome number reports XCIX. -Taxon 37: 397.

Hayek, A. von. 1911: Entwurf eines Cruciferen-systems auf phylogenetisher Grandlage. -Beih. Bot. Centralbl. 27: 127-335. Pls. 8-12.

Jacquemound, F. 1985: Observations sur le genre *Zerdana* Boiss. (Cruciferae). -Candollea. 40: 347-376.

Janchen, E. 1942: Das system der Cruciferen. -Osterr. Bot. Zeitsch. 91: 1-28.

Kupfer, Ph. 1980: Contribution a la cytotaxonomie de quelques Orophytes iraniens. -Rev. Biol. Ecol. Medit. 8: 37-48.

Maassoumi, A. A. R. 1980: Cruciferes de la flore d'Iran. Etude caryosystematique. Strasboug, universite louis posteur. These.

Monton, I. 1932: Introduction to the general cytology of Cruciferae. -Ann. Bot. 46: 506-556.

Mozaffarian, V. 1985: New species and new plant records from Iran. -Iran. Journ. Bot. 3 (1): 81-86.

- 1996: Studies on the flora of Iran, new species, new combinations and new records. -Iran. Journ. Bot. 7 (1): 127-142.

Nazarova, E. A. 1984: Chromosome numbers in the Caucasian representative of family Asteraceae, Brassicaceae, Fabaceae, Limoniaceae. -Bot. Zurn. SSSR. 69 (7): 972-975 (In Russian).

Podlech, D. 1986: Chromosomenstudien An pflanzen Des Saharo-sindischen Trockengebietes. -Mitt. Bot. München 22: 5-20.

Rodman, J. E. 1978: In IOPB chromosome number reports LXI. -Taxon 27: 375-392.

Rechinger, K. H. 1951: Cruciferae iranica novae vel minus cognitae. -Phyton, Horn 3: 44-68.

Rollins, R. C. 1966: Chromosome numbers of Cruciferae I. -Contr. Gray. Herb. 197: 43-65.

Schulz, E. O. 1936: Cruciferae, In. A. Engler & Prantl, Nat. Pflanzen. ed. 2. 17b: 226-658. Leipzig, W. Engelmann Verlag.

Zohary, M. 1966: Flora of Palaestina. vol. l. 246-328. -Israel. Ac. Sc.