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RESEARCH ARTICLE

STUDIES ON CHROMOSOMES OF APHIDS FROM BERTHIN REGION OF BILASPUR DISTRICT OF HIMACHAL PRADESH

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SUMMARY

Karyomorphology of 27 aphid species (including one undetermined) belonging to 14 genera, *Acyrthosiphon* (*A. gossypii* Mordvilko, 2n = 6), *Aphis (A. asclepiadis* Fitch, 2n = 8*, A. citricidus* (Kirkaldy), 2n = 8, *A. coreopsidis* (Thomas), 2n = 8, *A. craccivora* (Koch), 2n = 8, *A. fabae* Scopoli, 2n = 8, 9, *A. frangulae* Kaltenbach, 2n = 8, *A. gossypii* Glover, 2n = 8, *A. nerii* Boyer de Fonscolombe, 2n = 7, 8, *A. pomi* De Geer, 2n = 8, *A. spiraecola* Patch, 2n = 8, *Aphis* sp. 2n = 8), *Aulacorthum* (*A. solani* (Kaltenbatch), 2n = 10, *Brachymyzus (B. jasmini* A. N. Basu), 2n = 10, *Hydaphis* (*H. coriandri* (Das), 2n = 12, *Hyperomyzus* (*H. lactucae* (L.), 2n = 12, *Macrosiphoniella (M. sanborni* (Gillette), 2n = 12, *Melanaphis (M. pyraria* (Passerni), 2n = 8, 10, *Myzus* (*M. ornatus* Laing 2n = 12, M. persicae (Sulzer), 2n = 12), *Pentalonia* (*P,. nigronervosa* Coquerel), 2n = 13, 14), *Rhopalosiphum* (*R. maidis* (Fitch), 2n = 8, 10*, R., oxyacanthae* (Schrank)*,* 2n = 10*, R. padi* (Linnaeus) 2n = 8), *Schoutedenia* (*S. ralumensis* Rubsaamen, 2n= 16) and *Sitobion* (*S. miscanthi* (Takahashi), 2n = 16, 18) has been studied. The diploid chromosome number in these species ranged from 6 to 18. Karyotypic studies were made using photomicrographs of well spread metaphase plates. Chromosome lengths were measured at the metaphase stage. The total complement length and relative lengths were calculated for each species. Idiograms were constructed based on relative length data. The variations in chromosome number were observed in six species viz., *Aphis fabae* (2n = 8, 9), *A. nerii* (2n = 7, 8), *Melanaphis pyraria* (2n = 8, 10), *Pentalonia nigronervosa* (2n = 13, 14), *Rhopalosiphum maidis* (2n = 8, 10) and *Sitobion miscanthi* (2n = 16, 18).

Keywords: Aphids, holocentric chromosomes, karyotypes.

INTRODUCTION

Aphids constitute a group of soft bodied, sap sucking ancient insects that originated about 220 million years ago (Grimaldi & Engel 2005). There are about 5000 species of aphids (Favret 2018) out of which around 400 are serious pests of agriculture and forestry (Blackman & Eastop 1984). Aphid feeding causes weakening of the plants and in many cases, they also act as vectors of plant viruses (Kennedy et al. 1962).

The chromosomes of approximately 1039 aphid species have been reported so far (Gavrilov-Zimin et al. 2015). Aphids possess holocentric chromosomes, i.e. the centromeric activity is spread all along the length of chromosome (Blackman 1980b). Due to the holocentric nature of chromosomes aphids tend to have the exceptional chromosomal variations. The chromosomal variations also occur in aphids in relation to host plant (Blackman 1990) and different geographical conditions (Spence & Blackman 1998, Yang et al. 2000). Hence, the study of chromosomes of aphids from different host plants and geographical regions is desirable.

The aim of this study was to determine chromosome numbers and to contribute to the karyomorphological characteristics of various aphids viz., *Acyrthosiphon gossypii* Mordvilko, *Aphis asclepiadis* Fitch, *A. citricidus* (Kirkaldy), *A. coreopsidis* (Thomas), *A. craccivora* (Koch), *A. fabae* Scopoli, *A. frangulae* Kaltenbach, *A. gossypii* Glover, *A. nerii* Boyer de Fonscolombe, *A. pomi* De Geer, *A. spiraecola* Patch, *Aphis* sp., *Aulacorthum solani* (Kaltenbach), *Brachymyzus jasmini* A. N. Basu, *Hyadaphis coriandri* (Das), *Hyperomyzus lactucae* (L.), *Macrosiphoniella sanborni* (Gillette), *Melanaphis pyraria* (Passerni), *Myzus ornatus* Laing, *M. persicae* (Sulzer), *Pentalonia nigronervosa* Coquerel, *Protaphis middletonii* (Thomas), *Rhopalosiphum maidis* (Fitch), *R. oxyacanthae* (Schrank), *R. padi* (Linnaeus), *Schoutedenia ralumensis* Rubsaamen and *Sitobion miscanthi* (Takahashi) collected from Berthin region of Bilaspur district of Himachal Pradesh.

MATERIALS AND METHODS

For chromosomal studies, the collection of materials was made from various plants of the Berthin region (altitude of 673 m above sea level) in 2018 and embryos from parthenogenetic viviparous females were used. Young embryos were dissected by puncturing the posterior end of abdomen of these females and pretreated with 0.7% trisodium citrate solution for 25–30 min and fixed in 1:3 acetic acid-ethanol solution for 15–20 min at room temperature. They were then placed on a glass slide in a drop of 45% acetic acid for 3–5 min for squashing. A cover slip was put on the material with one edge extended outside the slide. The slide was then placed between two layers of blotting paper and tapped gently with the blunt end of the forceps. Cover slip was dislodged off the slide with a sudden jerk. Both slides and cover slips were then dried in a dust free chamber and after two d, stained in 2% Giemsa for 20–30 min. The slides and cover slips were mounted in DPX and kept in an oven at 60° C for overnight.

For photomicrography, well spread chromosome plates were selected and observed under Leica DMLS2 microscope. Karyotypes were made using these photomicrographs. The actual length of chromosomes was measured using an ocular micrometer. The total complement length was calculated for each species. From the actual lengths of chromosomes, the relative lengths were calculated. The idiograms were prepared based on relative length data.

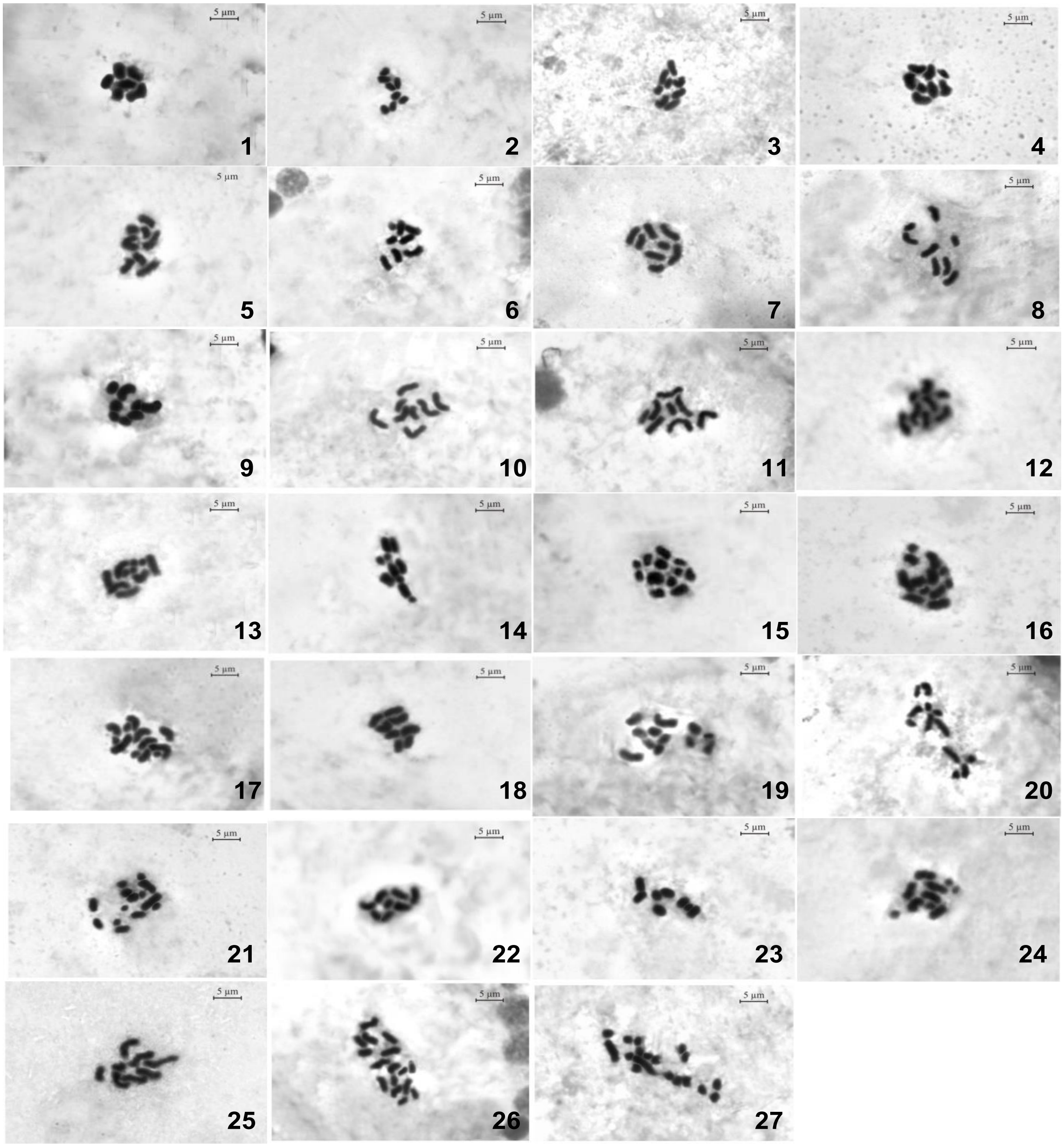
For species identification, keys developed by Blackman & Eastop (1984) were used.

OBSERVATIONS

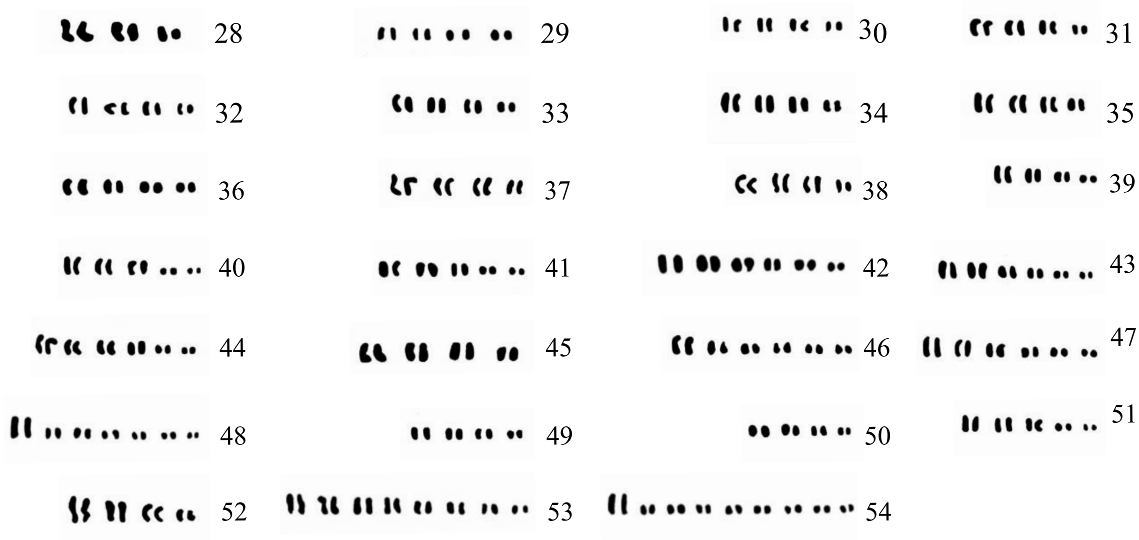
The details of the 27 aphid species and their host plants and karyotype analysis are given in Table I. The diploid chromosome number of these aphid species ranged from 6 to 18. The lowest diploid chromosome number of 2n = 6 has been reported in *Acyrthosiphon gossypii* and the highest number of 2n = 18 in *Sitobion miscanthi.* Out of 27species, fifteen had the diploid chromosome number of 8 viz., *Aphis asclepiadis*, *A. citricidus*, *A. coreopsidis*, *A. craccivora*, *A. fabae*, *A. frangulae*, *A. gossypii*, *A. nerii*, *A. pomi*, *A. spiraecola*, *Aphis* sp., *Melanaphis pyraria*, *P. middletonii*, R. *maidis* and *R. padi*. Three species had a diplod chromosome number of 10 viz., *Aulacorthum solani, B. jasmini* and *R. oxyacanthae*. Five species had a diploid chromosome number of 12 viz., *Hyadaphis coriandri*, *Hyperomyzus lactucae, Macrosiphoniella sanborni, Myzus ornatus* and *M. persicae. Pentalonia nigronervosa* and *Schoutedenia ralumensis* had 2n = 14 and 2n = 16, respectively.

TABLE I: Aphid species collected from different host plants and their karyotype analysis.

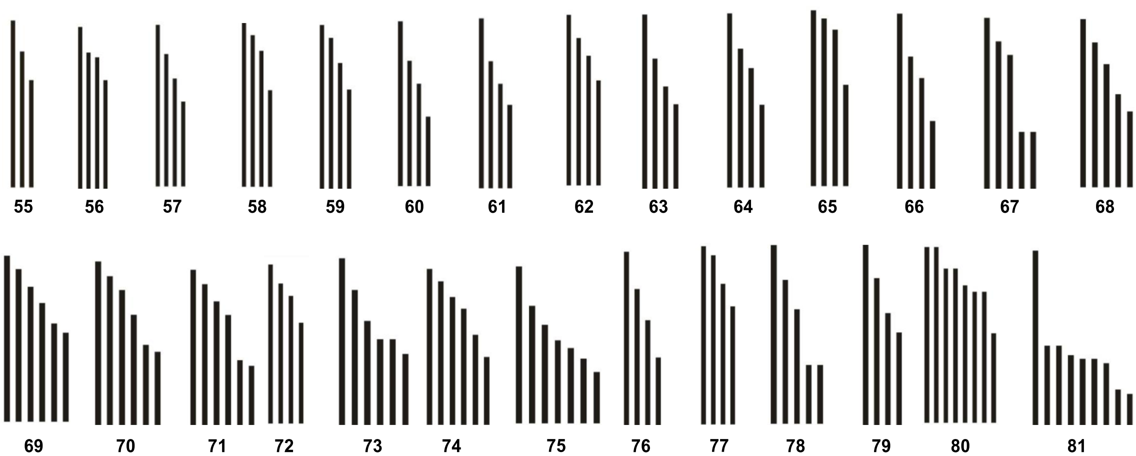
Species	2n	Host plant	Actual length (μm) ± S.E.		Relative length (μm) ± S. E.		Total complement length (μm) ± S.E.
			Shortest	Longest	Shortest	Longest	
Acyrthosiphon gossypii	6	*Vigna mungo*	2.73 ± 0.26	4.27 ± 0.43	13.10 ± 0.70	20.37 ± 0.64	20.89 ± 0.90
Aphis asclepiadis	8	*Malus* sp.	1.68 ± 0.05	2.48 ± 0.06	10.13 ± 0.14	15.02 ± 0.18	16.53 ± 0.45
A. citricidus	8	*Achyranthes aspera*	1.64 ± 0.05	3.30 ± 0.30	8.71 ± 0 .63	16.62 ± 0.48	19.59 ± 1.33
A. coreopsidis	8	*Solanum betaceum*	2.38 ± 0.18	4.06 ± 0.18	8.80 ± 0.60	14.96 ± 0.26	27.14 ± 0.57
A. craccivora	8	*Vigna unguiculata*	3.13 ± 0.09	5.10 ± 0.10	9.25 ± 0.03	15.12 ± 0.05	33.79 ± 0.79
A. fabae	8, 9	*Vigna unguiculata*	1.85 ± 0.20	4.34 ± 0.26	7.51 ± 0.53	17.80 ± 0.61	24.52 ± 1.59
A. frangulae	8	*Nepeta cataria*	1.75 ± 0.11	3.57 ± 0.24	8.63 ± 0.28	17.52 ± 0.43	20.38 ± 1.27
A. gossypii	8	*Abelmoschus esculentus*	2.70 ± 0.14	4.44 ± 0.31	9.50 ± 0.26	15.45 ± 0.30	28.56 ± 1.60
A. nerii	7, 8	*Gomphocarpus physocarpus*	1.95 ± 0.16	3.98 ± 0.29	8.65 ± 0.28	17.64 ± 0.50	22.56 ± 1.48
A. pomi	8	*Ageratum haustonium*	2.15 ± 0.10	4.55 ± 0.22	8.04 ± 0.38	16.91 ± 0.54	26.80 ± 0.66
A. spiraecola	8	*Ageratum* sp.	3.70 ± 0.10	6.40 ± 0.06	8.43 ± 0.23	14.63 ± 0.19	43.77 ± 0.90
Aphis sp.	8	*Legenephora moorie*	1.80 ± 0.06	4.57 ± 0.18	7.08 ± 0.07	17.93 ± 0.19	25.50 ± 1.08
Aulacorthum solani	10	*Bidens pilosa*	1.14 ± 0.06	3.40 ± 0.18	5.10 ± 0.37	15.00 ± 0.48	22.56 ± 0.75
Brachymyzus jasmini	10	*Jasminum* sp.	1.70 ± 0.05	4.03 ± 0.50	6.24 ± 0.29	13.90 ± 0.53	28.28 ± 2.40
Hyadaphis coriandri	12	*Foeniculum vulgare*	1.85 ± 0.06	3.43 ± 0.06	5.87 ± 0.06	10.92 ± 0.12	31.47 ± 0.90
Hyperomyzus lactucae	12	*Sonchus wightianus*	1.75 ± 0.07	3.91 ± 0.14	5.12 ± 0.05	11.48 ± 0.20	34.22 ± 1.43
Macrosiphoniella sanborni	12	*Chrysanthemum indicum*	2.03 ± 0.01	5.30 ± 0.09	4.55 ± 0.05	11.85 ± 0.04	44.78 ± 0.70
Melanaphis pyraria	8, 10	*Sorghum helepense*	3.22 ± 0.10	5.06 ± 0.09	9.57 ± 0.10	15.06 ± 0.19	33.65 ± 0.92
Myzus ornatus	12	*Ruellia simplex*	1.70 ± 0.04	4.03 ± 0.09	5.45 ± 0.09	12.87 ± 0.08	31.28 ± 0.63
M. persicae	12	*Barleria* sp.	2.13 ± 0.07	4.90 ± 0.05	4.84 ± 0.18	11.10 ± 0.13	44.11 ± 0.22
Pentalonia nigronervosa	13, 14	*Musa* sp.	0.96 ± 0.08	2.95 ± 0.23	3.97 ± 0.19	12.12 ± 0.67	24.27 ± 1.40
Protaphis middletonii	8	*Gossypium* sp.	1.95 ± 0.17	4.88 ± 0.33	7.10 ± 0.30	17.92 ± 0.44	27.46 ± 2.09
Rhopalosiphum maidis	8, 10	*Sorghum vulgare*, *Zea mays*	1.47 ± 0.09	2.20 ± 0.28	9.76 ± 0.33	14.69 ± 0.30	14.98 ± 0.58
R. oxyacanthae	10	*Coix – lacryma – jobi*, *Seteria viridis*	1.33 ± 0.11	4.03 ± 0.27	5.30 ± 0.30	16.12 ± 0.42	25.09 ± 1.71
R. padi	8	*Zea mays*	1.78 ± 0.10	3.52 ± 0.28	8.69 ± 0.20	16.98 ± 0.60	20.60 ± 1.17
Schoutedenia ralumensis	16	*Flueggea leucopyrus*	2.23 ± 0.07	4.40 ± 0.11	4.72 ± 0.19	7.64 ± 0.05	57.80 ± 1.79
Sitobion miscanthi	16, 18	*Cymbopogon goeringi*	0.93 ± 0.07	5.10 ± 0.10	2.39 ± 0.2	13.00 ± 0.51	39.53 ± 0.86



Figs 1─27: Somatic chromosomes of aphids. 1. *Acyrthosiphon gossypii.* 2. *Aphis asclepiadis.* 3. *A. citricidus.* 4. *A. coreopsidis.* 5. *A. craccivora.* 6. *A. fabae.* 7. *A. frangulae.* 8. *A. gossypii.* 9. *A. nerii.* 10. *A. pomi.* 11. *A. spiraecola.* 12. *Aphis* sp. 13. *Aulacorthum solani.* 14. *Brachymyzus jasmini.* 15. *Hyadaphis coriandri.* 16. *Hyperomyzus lactucae.* 17. *Macrosiphoniella sanborni.* 18. *Melanaphis pyraria.* 19. *Myzus ornatus.* 20. *M. persicae.* 21. *Pentalonia nigronervosa.* 22. *Protaphis middletonii.* 23. *Rhopalosiphum maidis.* 24. *R. oxyacanthae.* 25. *R. padi.* 26. *Schoutedenia ralumensis.* 27. *Sitobion miscanthi.*

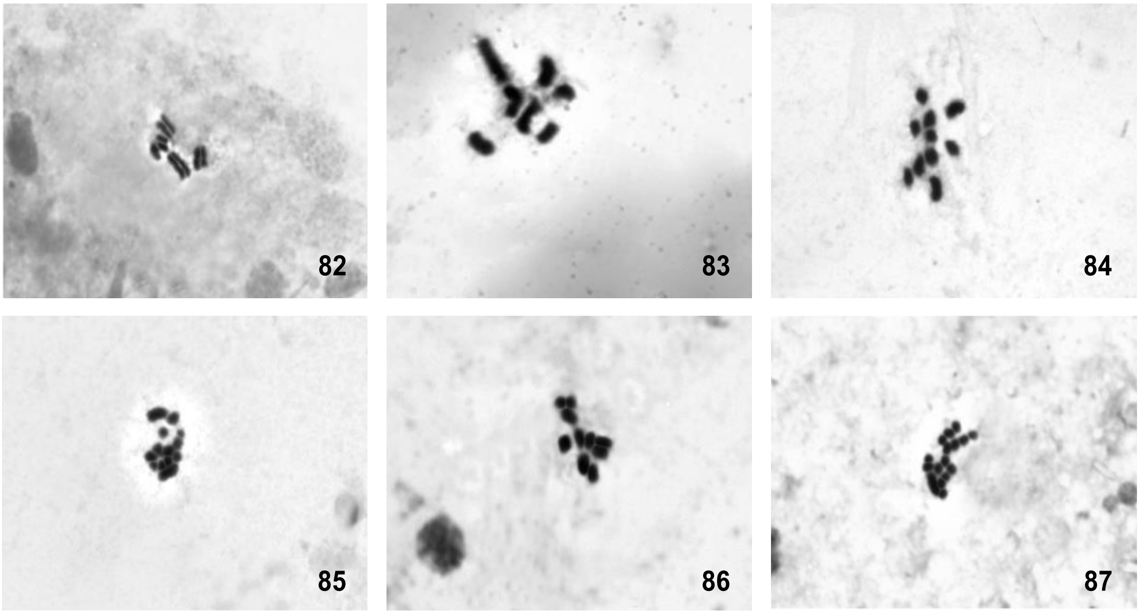


Figs 28─54: Karyotypes of aphids. 28. *Acyrthosiphon gossypii.* 29. *Aphis asclepiadis.* 30. *A. citricidus.* 31. *A. coreopsidis.* 32. *A. craccivora.* 33. *A. fabae.* 34. *A. frangulae.* 35. *A. gossypii*. 36. *A. nerii*. 37. *A. pomi.* 38. *A. spiraecola.* 39. *Aphis* sp. 40. *Aulacorthum solani.* 41. *Brachymyzus jasmini.* 42. *Hyadaphis coriandri.* 43. *Hyperomyzus lactucae.* 44. *Macrosiphoniella sanborni.* 45. *Melanaphis pyraria.* 46. *Myzus ornatus.* 47. *M. persicae.* 48. *Pentalonia nigronervosa.* 49. *Protaphis middletonii.* 50. *Rhopalosiphum maidis.* 51. *R. oxyacanthae.* 52. *R. padi.* 53. *Schoutedenia ralumensis.* 54. *Sitobion miscanthi.*



Figs 55─81: Idiograms of aphids. 55. *Acyrthosiphon gossypii.* 56. *Aphis asclepiadis.* 57. *A. citricidus.* 58. *A. coreopsidis.* 59. *A. craccivora.* 60. *A. fabae.* 61. *A. frangulae.* 62. *A. gossypii.* 63. *A. nerii.* 64. *A. pomi.* 65. *A. spiraecola.* 66. *Aphis* sp. 67. *Aulacorthum solani.* 68. *Brachymyzus jasmini.* 69. *Hyadaphis coriandri.* 70. *Hyperomyzus lactucae.* 71. *Macrosiphoniella sanborni.* 72. *Melanaphis pyraria.* 73. *Myzus ornatus.* 74. *M. persicae.* 75. *Pentalonia nigronervosa.* 76. *Protaphis middletonii.* 77. *Rhopalosiphum maidis.* 78. *R. oxyacanthae.* 79. *R. padi.* 80. *Schoutedenia ralumensis.* 81. *Sitobion miscanthi.*

Somatic metaphase plates and their corresponding karyotypes are depicted in Figs 1–27 and Figs 28–54, respectively. Idiograms of respective species are shown in Figs 55–81. In six species, variations in chromosome number also reported along with their normal diploid complement. These are, *Aphis fabae* (2n = 8, 9), *A. nerii* (2n = 7, 8), *Melanaphis pyraria* (2n = 8, 10), *Pentalonia nigronervosa* (2n = 13, 14), *Rhopalosiphum maidis* (2n = 8, 10) and *Sitobion miscanthi* (2n = 14, 16). Somatic metaphase plates of these aphid species in which variations reported are given in Figs 82–87.



Figs 82–87: Karyotypic variations in aphids. 82. *Aphis fabae*. 83. *A. nerii*. 84. *Melanaphis pyraria*. 85. *Pentalonia nigronervosa*. 86. *Rhopalosiphum maidis*. 87. *Sitobion miscanthi.*

DISCUSSION

In the present study, the diploid chromosome number in *Acyrthosiphon gossypii* was found to be six which is in conformity with earlier reports of Blackman (1980a). Likewise the chromosome number of 2n = 8 recorded in *Aphis asclepiadis, A. citricidus, A. craccivora, A. fabae, A. frangulae, A. gossypii, A. nerii, A. pomi* and *A. spiraecola* is in conformity with the reports made by earlier workers (Basu 1989, Blackman & Eastop 2015, Devi & Gautam 2012, Dutta & Gautam 1993, Gautam & Dhatwalia 2003, Gautam & Kumari 2003, Guleria & Gautam 2015, Kapoor & Gautam 1994, Kar & Khuda-Bukhsh 1988, Kulkarni & Karcker 1980, Kurl 1978, Robinson & Chen 1969 and Verma & Gautam 2015). However, the present report of 2n = 8 for *A. coreopsidis* and an undetermined species of *Aphis* are the first reports for these species. In two species, viz., *A. fabae* (2n = 9) (Fig. 82) and *A. nerii* (2n = 7) (Fig. 83) some of the cells also showed variations in diploid chromosome number. The former being hyperploid while the latter is hypoploid. The possible cause of variations is chromosomal fusion and fission.

Aulacorthum solani has the diploid chromosome number of ten as reported earlier by Kapoor & Gautam (1994) and Kuznetsova & Shaposhnikov (1973). Only one species of the genus *Brachymyzus* has been reported from India (Blackman & Eastop 2000). The diploid chromosome number of ten has been reported for the first time for *B. jasmini*. Chromosomes of one species of *Hyadaphis* were studied here. *H. coriandri* has the diploid chromosome number of 12. However, Blackman (1980a) and Blackman & Eastop (2015) reported the diploid chromosome number 12–14 for this species.

Hyperomyzus lactucae and *Macrosiphoniella sanborni* have 2n = 12 as reported earlier by Dutta & Gautam (1993) and Boschetti (1963) respectively. *Melanaphis pyraria* had the diploid chromosome number of eight. This confirms earlier reports of Blackman & Eastop (2015). Occasionally, cells with 2n = 10 (Fig. 84) were observed in the present study suggesting hyperploid condition in this species. Both the species of *Myzus* studied here (*M. ornatus* and *M. persicae*) showed the diploid chromosome number of 12 as reported by earlier workers (Blackman 1980a, Guleria & Gautam 2015, Kapoor & Gautam 1994 and Khuda-Bukhsh & Pal 1985). *Pentalonia nigronervosa* has the diploid chromosome number of 14. This confirms the earlier reports in this species (Panigrahi & Patnaik 1991). In the present study, some of the cells with a diploid chromosome number of 13 were observed suggesting a hypoploid condition (Fig.85). *Protaphis middletonii* has the diploid chromosome number of 8, which confirms earlier findings of Blackman & Eastop (2015).

Rhopalosiphum maidis has the diploid chromosome number of 8 as reported by Potan & Gautam (2019) and Samkaria et al. (2010). However, in the present study, cells with 2n = 10 have been observed, indicating a hyperploidy with 2 extra chromosomes in the complement (Fig. 86). Brown & Blackman (1988) also reported 2n = 10 in this species. *R. oxyacanthae* has the diploid chromosome number of 10, which confirms the earlier findings of Blackman & Eastop (2015). *R. padi* has the diploid chromosome number of 8 as reported by Robinson & Chen (1969).

Whereas Blackman (1980a) reported 2n=14 and 16 for *Schoutedenea ralumensis*, the present study revealed 2n=16 for this species. Kurl & Chauhan (1986) reported 2n = 14 for *Sitobion miscanthi.* In the present study, this species shows 2n=18 as reported earlier by Datta & Gautam (1993) and Kurl & Chauhan (1987). In addition, variation in chromosome number was observed with yet another diploid chromosome number of 16, deviating from the usual condition of 2n = 18 suggesting hypoploidy (Fig. 87).

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