Journal of Cytology and Genetics 2024 VOL. **25** (NS): 1–7

RESEARCH ARTICLE

ASSESSMENT OF DOWN SYNDROME WITH EMPHASIS ON CONGENITAL HEART DISEASE IN MALAPPURAM DISTRICT

V. JASEELA* AND H. HABEEBREHMAN

Postgraduate and Research Department of Zoology, Farook College, Kozhikode 673 632, Kerala

*For correspondence. Email: jaseelavelur@gmail.com

(Received 28 November 2023, revised accepted 15 December 2023)

SUMMARY The purpose of this study was to determine the occurrence of congenital heart disease (CHD), gender distribution and maternal age among individuals with Down syndrome (DS). The medical records of 112 individuals with DS were reviewed. Out of the 112 individuals, 50.9% were male and 49.1% were female. Among them, 45 (40.2%) had CHD. This study revealed that the frequency of DS was higher in younger mothers (≤30 y) and found no influence of gender or maternal age on the incidence of CHD in individuals with DS. The association between CHD and DS is a common clinical feature with a high prevalence. However, CHD was not found to be associated with the gender or maternal age of individuals with DS. Males were found to be more likely to have DS than females and young mothers below 30 y of age were found to be at higher risk due to early marriage and multiparity in women.

Keywords: Down syndrome, congenital heart disease, maternal age.

INTRODUCTION

Aneuploidy refers to an abnormal number of chromosomes due to an extra or missing chromosome in the diploid complement. Down syndrome (DS) is the most common chromosomal aneuploidy that occurs frequently. It is a genetic disorder caused by the triplication of chromosome 21, resulting in a total of 47 chromosomes instead of 46. The frequency of DS is estimated to be 1 in every 650–1000 livebirths worldwide (Hassold & Sherman 2000). In India, it is estimated that there are 23000–29000 children born with DS every year, which is the highest in the world. India ranks twelfth in the rate of birth of children with DS worldwide, based on 405 published studies on DS research between 1973 and 2012 (Siwach Anil 2015).

DS was first described by John Langdon Down, a physician, in 1866 when he published an article about children with common phenotypic features and intellectual disability (Down 1866). Different types of phenotypic characters are displayed in individuals with DS, but the level of features varies from person to person. The most commonly observed phenotypic characters include a flat nasal bridge, poor muscle tone,

small head, upward slanting eyes, epicanthic folds, small ears, small mouth, single palmar crease, large tongue and large space between the toes. Many internal complications can also be present, such as intellectual disability, autistic behaviour, Alzheimer's disease, malformed intestines, congenital heart diseases (CHDs), Hirschsprung disease, celiac disease, hypothyroidism, diabetes, cataracts and glaucoma.

Among the medical complications, CHD is the most common and frequently occurring disease in individuals with DS. CHD refers to a heart defect or problem in heart function that is present at birth. The association between DS and CHD is common (Freeman et al. 1998). The prevalence of CHD is estimated to be 1–150/1000 livebirths worldwide, with a higher rate in India of 2.2–50.89 per 1000 livebirths (Smitha et al. 2006). The frequency of CHD in individuals with DS is estimated to be 40–60% (Khoury & Erickson 1992). The life expectancy of individuals with DS depends on the related diseases, such as CHD and respiratory problems, which can have a significant impact during the early years of life (Cua et al. 2017, Hoffman & Kaplan 2002). The pattern of CHD varies globally and is influenced by sociodemographic, genetic and geographic factors. The most commonly occurring heart defects in individuals with DS include atrioventricular canal defects (AVCD), ventricular septal defects (VSD), patent ductus arteriosus (PDA), atrial septal defects (ASD), and tetralogy of Fallot. However, the mortality rate has decreased in recent times due to modern medical treatments such as surgical interventions for CHD, which can improve the quality of life. Early diagnosis is key to improving the lives of individuals with DS and CHD (Kabbani et al. 2005, Roussot et al. 2006).

Gender distribution in DS has been studied by several researchers and it has been observed that there is a male predominance as compared to female. The male-to-female ratio is typically distributed as 1.1:1 to 2.3:1. The genetics of male predominance in DS have been studied and it was shown that during spermatogenesis, the joint segregation of chromosome 21 and Y and these spermatozoa with Y chromosomes cause non-disjunction in the second meiotic division of oogenesis (Kovaleva 2002).

Advanced maternal age is a significant risk factor for the occurrence of DS. Several researchers have postulated various hypotheses to explain the correlation between the birth of children with DS and advanced maternal age. Penrose (1933, 1934) postulated a hypothesis linking birth of children with DS to advanced maternal age through nondisjunction. Brook et al. (1984) proposed a hypothesis that biological aging, as the main factor, increases the rate of meiotic error and aneuploid birth depending on the biological age of the ovary rather than the chronological age of women. Ghosh et al. (2010) proposed a hypothesis of genetic aging, stating that the genetic age of mothers with DS children is

higher than the mothers of normal children. Approximately 90% of trisomy cases are due to chromosomal nondisjunction during maternal meiotic division, with a higher frequency of nondisjunction occurring in the first meiotic division as compared to the second meiotic division (Yoon et al. 1996).

This study aimed to identify the frequency of CHD, gender distribution and maternal age among individuals with DS in the study area. Additionally, the study aimed to determine the influence of gender and maternal age on CHD in individuals with DS.

MATERIALS AND METHODS

Data was collected from 112 individuals with DS in the Malappuram district of Kerala, through a structured questionnaire filled out by the patient's parents and medical records of DS. The presence of DS was confirmed through phenotypic features and karyotyping results and CHD was confirmed through medical reports. This study was conducted with the permission of the Directorate of Women and Child Developmental Cell, Thiruvananthapuram. Statistical analysis was performed using Microsoft Excel and SPSS. Tables and figures were created in Excel, and the chi-square test was applied in SPSS to examine the relationship between gender and maternal age and the incidence of CHD in individuals with DS. This study was conducted after obtaining ethical approval from the Calicut University Human Ethics Committee. The information was collected from the parents of the 112 individuals with DS who participated in the study after obtaining informed consent in their native language. The information collected was published in a statistical format and does not reveal individual information, so further consent was not required for this study.

OBSERVATIONS

The results of this study are presented in Tables 1 and 2 and depicted in figures 1 to 3. Out of the 112 individuals with DS, 45 were born with CHD and 67 were without CHD which means that 40.2% DS individual were born with CHD (Table1, Fig. 1). There were 57 males and 55 females born with DS (Table 1, Fig. 2). In the present study, only a slight change is seen in the gender distribution. DS is found predominantly in male than in female. We evaluate the mother age in 2 aspects, one is the age less than or equal to 30 y and other is more than 30 y. The majority of mothers with frequency of 66 y were under the age of 30 y at the time of birth of the individual with DS. 66% of mother age is under the age less than or equal to 30 y when compared with the age of more than 30 y with 46% (Table 1, Fig.3).

Analysis of gender and maternal age on the incidence of CHD using a chi-square test showed that there was no significant relationship between gender and CHD ($p = 0.263$) or maternal age and CHD ($p = 0.173$) indicating that the incidence of CHD among DS people is independent of the gender and maternal age (Table 2).

TABLE 1: Distribution of CHD, gender and maternal age of DS.

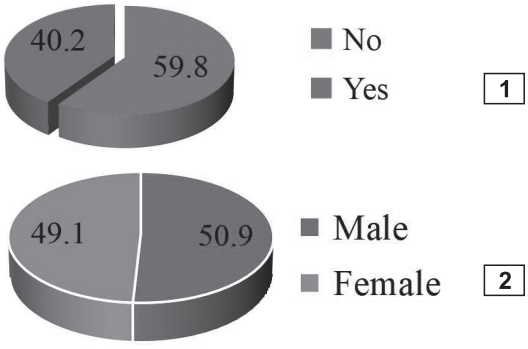
Character	Frequency	Percentage
Without CHD	67	59.8
With CHD	45	40.2
Gender		
Male	57	50.9
Female	55	49.1
Maternal age		
≤20	15	13.4
21–30	51	45.5
31–40	33	29.5
41–50	11	9.8
>50	2	1.8
TOTAL	112	100

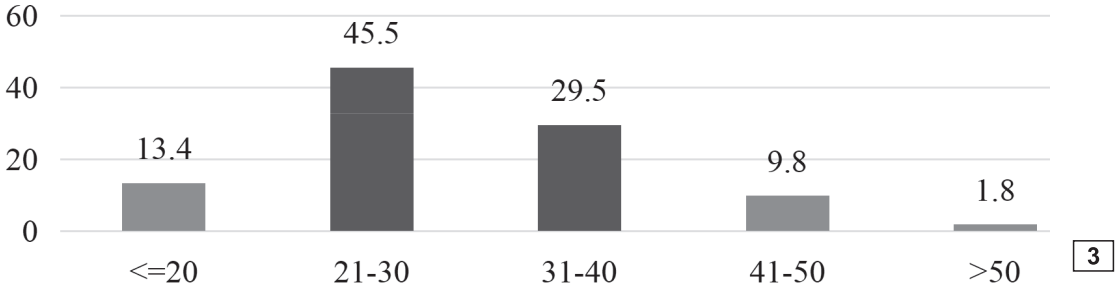
TABLE 2: Gender and maternal age effect on CHD among DS.

Characters	Frequency and percentage of CHD		p-value
	Without CHD	With CHD	
Gender			
Male	37 (55.2)	20 (44.4)	0.263
Female	30 (44.8)	25 (55.6)	
Maternal age			
≤30	36 (53.7)	30 (66.7)	0.173
>30	31 (46.3)	15 (33.3)	

DISCUSSION

In this study, the frequency of CHD in individuals with DS was found to be 40.2%, which is consistent with previous data ranging from 30–65% (Irving & Chaudhari 2012, Murthy et al. 2007). CHD is a common occurrence in individuals with DS, with reported frequencies ranging from 35–65%, and our results agree with these findings (Ashraf et al. 2010, Venugopalan& Agarwal 2003). The study reported a higher number of male participants (57) as compared to female participants (55) with DS, which is in line with the findings of other studies (Bianca et al. 2001, El-





Figs 1–3: 1. Pie diagram showing the distribution of CHD among DS. 2. Pie Diagram showing gender distribution of DS. 3. Column diagram showing distribution of maternal age at the time conception of DS.

Gilany et al. 2011). Some researchers have proposed different explanations for this prevalence of male DS, including the segregation of chromosome 21 with Y chromosome during spermatogenesis and paternal nondisjunction (Soares et al. 2001). Advanced maternal age is one of the risk factors for DS. After 35 y, the risk of incidence of DS increases. However, in our study, DS was found to be most frequent among mothers who were younger than 30 y at the time of birth, which is similar to some other studies (Bertelli et al. 2009, John & Gayathri 2022, Otaigbe et al. 2012). The mean maternal age in our study was 29.68 y and supports the findings of the study by Dey & Sujay Ghosh (2005). The DS frequency is higher in the younger mother due to the early-aged marriage and multiparity among South Indian population (Anuspandana et al. 2017).

The relationship between gender, maternal age and DS with CHD was analyzed using statistical tools. The chi-square test was applied to the data. The present study found no relationship between gender and CHD in people with DS, which is similar to the studies conducted by Morsy et al. (2016) and Sharifi et al. (2018). The CHD and maternal age also showed no relationship, as found in the studies by Freeman et al. (1998) and Khoury & Erickson (1992).

In conclusion, this study highlights the high prevalence of CHD in individuals with Down syndrome and the importance of early diagnosis and treatment. Additionally, it confirms the predominant occurrence of male individuals with DS, and that younger maternal age may increase the risk of DS. However, there is no significant relationship between gender and maternal age and the incidence of CHD in individuals with DS.

ACKNOWLEDGEMENTS

We would like to express our special gratitude to Principal, Farook College and Head of the Department of Zoology for providing the facilities and University Grant Commission, New Delhi, for the award of Moulana Azad National Fellowship to VJ. Also grateful to K. Fazil and Manzoor Babu for their help and support while conducting statistical analysis and plagiarism check respectively for this article.

REFERENCES

ANUSPANDANA MAHAPATRA, RACHITA SARANGI & AVANTIKA DHANAWAT 2017 Congenital heart disease in Down syndrome-spectrum in tertiary care hospital *Int J Sci Res* **6** 263–265

ASHRAF MOHD, MALLA A REYAZ, CHOWDHARY JAVED, MOHD IRSHAD, AKHTER MYMOONA, RAHMAN AYAZ & SALEEM JAVED 2010 Consanguinity and pattern of congenital heart defects in Down syndrome in Kashmir India *Am J Sci Ind Res* **1** 573–577

BERTELLI E C P, BISELLI J M, BONFIM D, GOLONI-BERTOLLO E M 2009 Clinical profile of children with Down syndrome treated in genetics outpatient service in the southeast of Brazil *Rev Assoc Med Bras* **55** 547–552

BIANCA S, BIANCA M & ETTORE G 2001 Sex ratio imbalance and Down's syndrome newborns *J Perinat Med* **29** 266–267

BROOK J D, GOSDEN R G & CHANDLEY A C 1984 Maternal ageing and aneuploid embryos evidence from the mouse that biological and not chronological age is the important influence *Hum Genet* **66** 41–45

CUA C L, HAQUE U, SANTORO S, NICHOLSON L & BACKES C H 2017 Differences in mortality characteristics in neonates with Down's syndrome *J Perinatol* **37** 427–431

DEY S K & SUJOY GHOSH 2005 PCR-Based detection of parental origin of extra chromosome 21 in Down syndrome *Int J Hum Genet* **5** 183–186

DOWN J L 1866 Observations on an ethnic classification of idiots *London Hosp Clini Lect Rep* **3** 259–262

EL-GILANY A H, YAHIA S, SHOKER M & EL-DAHTORY F 2011 Cytogenetic and comorbidity profile of Down syndrome in Mansoura University Children's Hospital Egypt *Indian J Hum Genet* **17** 157–163

FREEMAN S B, TAFT L F, DOOLEY K J, ALLRAN K, SHERMAN S L, HASSOLD T J, KHOURY M J & SAKER D M 1998 Population-based study of congenital heart defects and Down syndrome *Am J Med Genet* **80** 213–217

GHOSH S, FEINGOLD E, CHAKRABORTY S & DEY S K 2010 Telomere length is associated with types of chromosome 21 nondisjunction: a new insight into the maternal age effect on Down syndrome birth *Hum Genet* **127** 403–409

HASSOLD T & SHERMAN S 2000 Down syndrome: genetic recombination and the origin of the extra chromosome 21 *Clin Genet* **57** 95–100

HOFFMAN J I & KAPLAN S 2002 The incidence of congenital heart disease *J Am Coll Cardiol* **39** 1890–1900

IRVING C A & CHAUDHARI M P 2012 Cardiovascular abnormalities in Down's syndrome: spectrum management and survival over 22 years *Arch Dis Child* **97** 326–330

JOHN S T & GAYATHRI K 2022 Screening of mothers to detect Down syndrome: a practical in a resource limited setting *Int Contemp Pediatr* **9** 566–570

KABBANI M S, GIRIDHAR S, ELBARBARY M, ELGAMAL M A, NAJM H & GODMAN M 2005 Postoperative cardiac intensive care outcome for Down syndrome children *Saudi Med J* **26** 943–946

KHOURY M J & ERICKSON J D 1992 Improved ascertainment of cardiovascular malformations in infants with Down's syndrome Atlanta 1968 through 1989 Implications for the interpretation of increasing rates of cardiovascular malformations in surveillance systems *Am J Epidemiol* **136** 1457–1464

KOVALEVA N V 2002 Sex ratio in DS (Article in Russian) *Tsitol Genet* **36** 54–69

MORSY M M, ALGRIGRI O O, SALEM S S, ABOSEDERA M M, ABUTALEB A R, AL-HARBI K M, AL-MOZAINY I S, ALNAJJAR A A, HABEB A M & ABO-HADED H M 2016 The spectrum of congenital heart diseases in down syndrome A retrospective study from northwest Saudi Arabia *Saudi Med J* **37** 767–772

MURTHY S K, MALHOTRA A K, MANI S, SHARA M E, AL-ROWAISHED E E, NAVEED S, ALKHAYAT A I & ALALI M T 2007 Incidence of Down syndrome in Dubai *UAE Med PrincPract* **16** 25–28

OTAIGBE B E, TABANSI P N & AGBEDEYI G O 2012 Pattern of congenital heart defects in children with Down syndrome at the University of Port Harcourt Teaching Hospital Port Harcourt *Niger J Paed* **39**164–167

PENROSE L S 1933 The relative effect of paternal and maternal age in Mongolism *J Genet* **27** 219–224

PENROSE L S 1934 The relative etiological importance of birth order and maternal age in Mongolism *Proc Royal Soc B Biol Sci* **115** 431–450

ROUSSOT M A, LAWRENSON J B, HEWITSON J, SMART R & DE DECKER H P 2006 Is cardiac surgery warranted in children with Down syndrome? A case-controlled review *SAMJ* **96** 924–930

SHARIFI A, MANSOOR A, IBRAHIMI M, WALI A, WALI W & EKRUN K 2018 Congenital heart disease in

children with Down syndrome in Afghanistan *PI [Internet]* **58** 312

SIWACH ANIL 2015 Mapping of India's contribution on Down syndrome during 40 years from 1973–2012 *Int Lett Nat Sci* **34** 21—33

SMITHA R, KARAT S C, NARAYANAPPA D, KRISHNAMURTHY B, PRASANTH S N & RAMACHANDRA N B 2006 Prevalence of congenital heart diseases in Mysore. *Ind J Hum Genet* **12** 12–17

SOARES S R, TEMPLADO C, BLANCO J, EGOZCUE J & VIDAL F 2001 Numerical chromosome abnormalities in the spermatozoa of the fathers of children with trisomy 21 of paternal origin: generalised tendency to meiotic non-disjunction *Hum Genet* **108** 134–139

VENUGOPALAN P & AGARWAL A K 2003 Spectrum of congenital heart defects associated with Down syndrome in high consanguineous Omani population *Indian Pediatr* **40** 398–403

YOON P W, FREEMAN S B, SHERMAN S L, TAFT L F, GU Y, PETTAY D, FLANDERS W D, KHOURY M J & HASSOLD T J 1996 Advanced maternal age and the risk of Down syndrome characterized by the meiotic stage of chromosomal error: a population-based study *Am J Hum Genet* **58** 628–633

Journal of Cytology and Genetics 2024 VOL. **25** (NS): 9–13

RESEARCH ARTICLE

A STUDY ON THE CHROMOSOMES OF APHIDS OF SOME COMMON PLANTS OF HIMACHAL PRADESH

RITU SHARMA[1], MEENA KUMARI[2], DEVIKA VAIDYA[3], SEEMA SHARMA[3] AND SARITA KUMARI[2]*

[1] Department of Zoology, Gautam Group of Colleges, Hamirpur 177 001

[2]Department of Biosciences, Himachal Pradesh University, Summer Hill, Shimla 171 005

[3]Department of Chemistry, Vallabh Government College, Mandi 175 001

* For correspondence. Email: choudharysarita701@gmail.com

(Received 13 November 2023, revised accepted 16 December 2023)

SUMMARY The present study was undertaken to investigate the karyotypes of 4 species of aphids, viz., *Acyrthosiphon pisum, Brevicoryne brassicae, Lipaphis erysimi* and *Metopolophium malvae* infesting *Pisum sativum, Raphanus sativus, Brassicae campestris* and *Geranium* sp. respectively. *A. pisum* and *M. malvae* have the diploid chromosome number of 8 and *L. erysimi* and *B. brassicae* show 2n = 10 and 16 respectively. Karyotypes were analysed and idiograms were constructed with the help of actual length data and relative length. In all 4 species, there is a gradual decrease in the size of chromosomes in the diploid complement.

Keywords: Chromosomes number, aphids, karyotype, actual length, idiogram.

INTRODUCTION

Aphids are the most prominent pests of various agricultural and horticultural crops and damage them by sucking the plant sap as well as by transmitting a number of viral diseases (Kennedy et al. 1962). Most of the aphids are heteroecious, exploiting both primary and secondary hosts. Aphids can increase their population by polymorphism, viviparity and thelytokous reproduction with a high rate in a very limited time; these are exclusive phenomena in their life cycles (Dixon 1985). Aphids have peculiar cytological features due to the presence of holocentric chromosomes. Approximately 5000 aphid species have been identified globally, of which 510 genera are known to exist and infest about 300 plant families. (Blackman & Eastop 2000, 2006, 2015, Favret 2015, Gavrilov-Zimin et al. 2015). Cytologically, only 750 species are known (Kuznetsova & Shaposhnikov 1973, Gut 1976, Blackman 1980, Gautam & Sharma 1990, Khuda-Buksh & Kar 1990, Dutta & Gautam 1993). Generally, in aphids, most genera show remarkable constancy in their chromosome numbers while some chromosome numbers have been more liable to change in the course of speciation (Blackman 1980). Aphids show intraspecific variations in karyotypes because of holocentric chromosomes. So if a holocentric chromosome breaks into two or more parts, the fragments can still move independently into daughter cells while in chromosomes with localized centromere, the fragments tend to be eliminated at mitosis (Ris 1942). The aphid fauna

of Himachal Pradesh have been taxonomically described by Ghosh (1986). He reported the occurrence of 186 species. Cytological studies on the aphid fauna of Himachal were carried out by several workers (Kulkarni & Kacker 1980, 1981, Kurl & Chauhan 1986, Gautam & Sharma 1990, Kapoor & Gautam1994, Gautam & Kumari 2003, Samkaria et al. 2010, Khagta & Gautam 2016, Sharma & Gautam 2019, Anupriya & Kumari 2021, Singh et al. 2021, Kumari et al. 2022,). As karyotype variations have been reported to occur frequently in several aphid species, it is desirable to investigate the chromosomes of aphids infesting different host plants. All 4 species of the present study are reinvestigated. This effort helps in understanding of the nature of holocentric chromosomes and different cytogenetic processes in aphids' life cycles. These studies may prove useful in determining the adaptability of aphid species to different geographical and environmental conditions occurring in most common plants as well as in ascertaining the evolution of their karyotypes. The present paper deals with the karyotypes of *Acyrthosiphon pisum, Brevicoryne brassicae, Lipaphis erysimi* and *Metopolophium malvae.*

MATERIALS AND METHODS

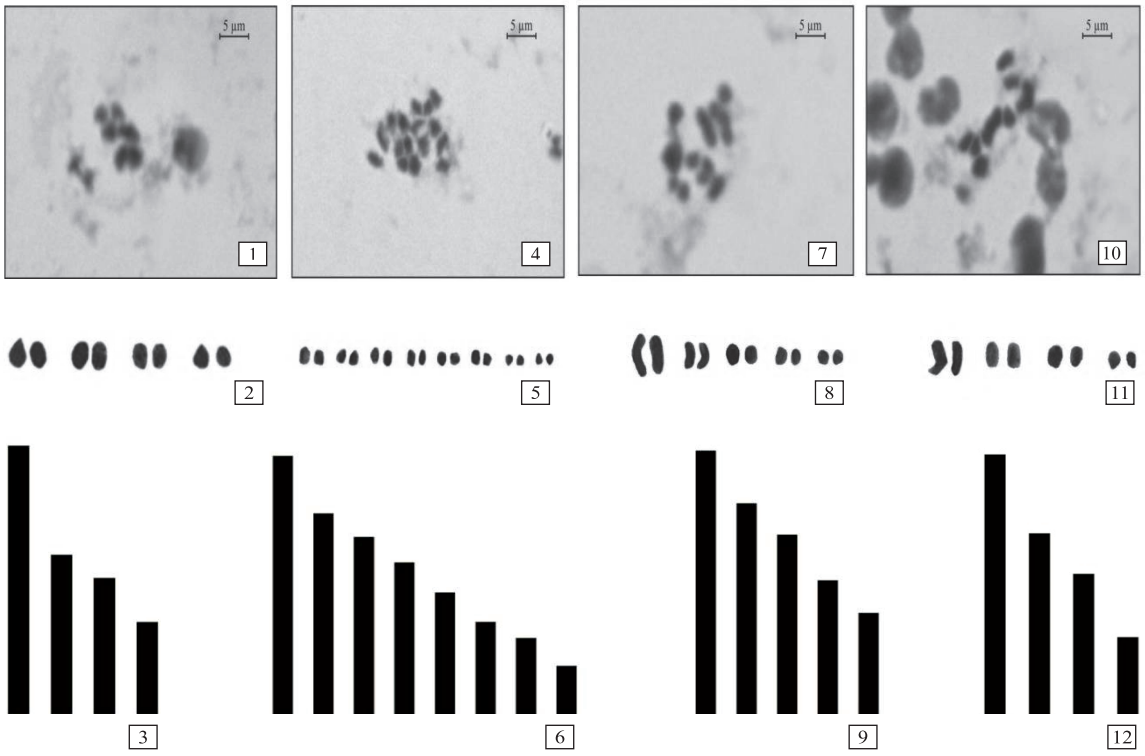
For the collection of material, the field survey was carried out in different areas of Himachal Pradesh. The infested arial parts like twigs, leaves, stem and inflorescence of host plants (*Pisum sativum, Raphanus sativus, Brassicae campestris* and *Geranium* sp.) were cut out and collected in small polythene bags for identification and cytological studies. Aphids along with their host plants were noted down along with the place of collection of aphids.

For cytological studies, embryos were taken out by puncturing the posterior end of parthenogenetic aphids. Only young embryos in which there was no eye colour pigment were taken. These embryos were pretreated with 0.7% tri sodium citrate solution for 30 min and were fixed in 1:3 acetic-ethanol for 10–15 min. The squashing of embryos was done by putting them on a glass slide with a drop of 50% acetic acid for 3–5 min and a cover slip was placed with a liable edge extending outward. Then the slide was pressed with the thumb. The cover slip was dislodged off the slide with a sudden jerk. Slides and cover slips were dried at room temperature in a dust-free chamber. Staining was done with a 2% Giemsa solution. After staining, slides and cover slips were placed in a working solution for 30 min and excess of stain was removed and dried again. Permanent slides were observed and photomicrographs of the best plates were taken. The actual lengths of chromosomes were measured using an ocular micrometer. From the actual lengths data, total complement lengths and relative lengths were calculated and idiogram for each species was constructed by using relative length data.

OBSERVATIONS

A. pisum (Harris)

This species has a diploid chromosome number of 8 (Figs 1, 2). The actual lengths of the shortest and longest chromosomes were 1.97 μm ± 0.04 and 5.82 μm ± 0.30 respectively. The total complement length is 28.30 μm ± 0.79. Relative length



Figs 1–12: Cytology of of aphids**.** 1–3. *A. pisum*. 1. Somatic metaphase. 2. Karyotype. 3. Idiogram. 4–6. *B. brassicae*. 4. Somatic metaphase. 5. Karyotype. 6. Idiogram. 7–9. *L. erysimi*. 7. Somatic metaphase. 8. Karyotype. 9. Idiogram. 10–12. *M. malvae*. 10. Somatic metaphase. 11. Karyotype. 12. Idiogram. (Scale = 5 µm)

ranges from 7.02 ± 0.32 to 20.45 ± 0.78. An Idiogram of this aphid revealed that one pair of chromosomes is long, 2 pairs are medium and one pair is short (Fig. 3).

***B. brassicae* (L.)**

The diploid chromosome number in *B. brassicae* is 16 (Figs 4, 5). The length of chromosomes varies from 1.00 µm ± 0.07 to 5.26 µm ± 0.08. The total complement length was 46.02 µm ± 0.17 and relative length ranges from 2.17 ± 0.16 to 11.43 ± 0.17. Idiogram of this species showed one pair of long, 4 pairs of medium and 3 pairs of short chromosomes (Fig. 6).

***L. erysimi* (Kaltenbach)**

This species has a diploid chromosome number of 8 (Figs 7, 8). The length of chromosomes ranges from 1.82 µm ± 0.12 to 4.76 µm ± 0.26 and the total complement length is 32.16 µm ± 1.76. The relative lengths of chromosomes vary from 5.70 ± 0.18 to 14.82 ± 0.30. The idiogram shows one pair of long chromosomes, 2 pairs of medium and 2 pairs of short chromosomes (Fig. 9).

***M. malvae* (Mosley)**

In this species, the diploid chromosome number was 8 (Figs 10, 11). The actual lengths of the shortest and longest chromosomes were 1.52 µm

± 0.13 and 5.02 µm ± 0.15 respectively. The total complement length was 25.25 µm ± 0.50. The relative lengths of chromosomes ranges from 5.9 ± 0.43 to 19.69 ± 0.50. The idiogram shows one pair of long chromosomes, one pair of medium size and 2 pairs of short chromosomes (Fig. 12).

DISCUSSION

Four species studied here have 3 different chromosome numbers. Whereas *A. pisum* and *M. malvae* have 2n = 8. The other 2 species *L. erysimi* and *B. brassicae* have 2n = 10 and 16 resprctively.

The diploid chromosome number of *A. pisum* is in conformity with the earlier reports (Pagliai 1965, Robinson & Chen 1969a, Blackman 1980, 1986, Khuda-Bukhsh & Kar 1990). However, in *A. kondi, A. loti, A. peialrgonii,* Blackman (1980) reported 2n = 10. Robinson & Chen (1969a) also reported 2n =10 in *A. caragenae.*

In *B. brassicae*, the diploid chromosome number was16, as reported by Robinson & Chen (1969b), Colling (1955), Cognetti (1961), Dutta & Gautam (1993) and Kapoor & Gautam (1994). However, Kulkarni (1984) reported 2n = 14 in this species.

L. erysimi has a diploid chromosome number of 10 which is in conformity with the reports of earlier workers (Gut 1976, Kulkarni & Kacker 1979). However, Blackman (1980) while reporting 2n = 9 in this species attributed these variations to the fusion and fragmentation of chromosomes. Kar & Khuda-Bukhsh (1991) reported 2n = 8 in this species and according to them, dissociation of 1 or 2 fragments might have led to the origin of 2n = 9 or 10 in this species.

M. malvae has a diploid chromosome number of 8. The other species of the genus *Metapolophium* are reported to have variable chromosome numbers such as 2n = 16 in *M. frisicum* (Blackman 1980) and 2n = 18 in *M. dirhodum* (Robinson & Chen 1969a).

ACKNOWLEDGEMENT

The fellowship awarded to Sarita Kumari by the Indian Council of Medical Research, New Delhi is gratefully acknowledged.

Authors' contributions

Ritu Sharma and Sarita Kumari prepared the manuscript, and Meena Kumari edited and drafted it. Aphids' collections and field visits were assisted by Devika Vaidya and Seema Sharma.

Declarations

We hereby declare that every aspect of this manuscript is original. It has not been partially or entirely published in any other language and is not being considered for publication anywhere.

Conflict of interest

All authors declare that they have no conflict of interest.

Consent to participate

All authors agree with the content of this manuscript and with its publication.

REFERENCES

ANUPRIYA P & KUMARI M 2021 Chromosome studies on four species of *Aphis* infesting food crops *J Cytol Genet* **22** (NS) 49–53

BLACKMAN R L 1980 Chromosome numbers in the Aphididae and their taxonomic significance *Syst Entomol* **5** 7–25

BLACKMAN R L 1986 The chromosomes of Japanese Aphididae (Homoptera) with notes on the cytological

work of Orihay Shinji *Cytologia* **51** 59–83

BLACKMAN R L & EASTOP V F 2000 *Aphids on world's crops*: *an identifification and information guide* 2nd ed John Wiley & Sons Chichester London

BLACKMAN R L & EASTOP V F 2006 *Aphids on the world's herbaceous plants and shrub: An identification and information guide* John Wiley & Sons Chichester London

BLACKMAN R L & EASTOP V F 2015 *Electronic database: "Aphids on the world's plants" http://www.aphidsonworldsplants.info*

COGNETTI G 1961 Citogenetica della partenogenicsi negli Afidi *Arch Zool Ital* **46** 89–122

COLLING A W 1955 Aphid chromosomes *Nature* **176** 207–208

DIXON A F G 1985 *Aphid ecology* Blackie & Sons Bishopbriggs Glasgow

DUTTA J & GAUTAM D C 1993 Chromosomes of aphid fauna from north-western Himalayas India *Cytologia* **58** 367–375

FAVRET C 2015 Aphid species File version 5.0/5.0. Retreived from http://Aphid.Species File.org.

GAUTAM D C & KUMARI M 2003 Karyotype of *Aphis pomi* De Geer First report from India *J Cytol Genet* **4** (NS) 95–96

GAUTAM D C & SHARMA R K 1990 Chromosome numbers and idiograms of seven species of aphids from north-western Himalayas *Chrom Inf Serv* **49** 16–18

GAVRILOV-ZIMIN I A, STEKOLSHCHIKOE A V & GAUTAM D C 2015 General trends of chromosomal evolution in Aphidococca (Insecta Homoptera Aphidinea + Coccinea) *Comp Cytogenet* **9** 335–422

GHOSH L K 1986 *A conspectus of Aphididae (Homoptera) of Himachal Pradesh in north-west Himalayas* India technical monograph Zoological Survey of India Kolkata

GUT J 1976 Chromosome numbers of parthenogenetic females of fifty-five species of Aphididae (Homoptera) new to cytology *Genetica* **46** 279–285

KAPOOR L & GAUTAM D C 1994 Karyotypic studies in aphids from Himachal Pradesh (north-western Himalayas) India *Cytologia* **59** 159–164

KAR I & KHUDA-BUKHSH A R 1991 Nucleolar organizer regions (NORs) in the chromosomes of an aphid *Lipaphis erysimi* Kalt (Homoptera: Aphididae) with variable chromosome numbers *Cytologia* **56** 83–86

KENNEDY J S, DAY M F & EASTOP V F 1962 *A conspectus of aphids as vectors of plant viruses* Commwealth Institute of Entomology London

KHAGTA P & GAUTAM D C 2016 Chromosomal studies on six species of crop aphids from Himachal Pradesh *Nucleus* **59** 1–4

KHUDA-BUKHSH A R & KAR I 1990 Karyotypic studies in twenty seven species of aphids (Homoptera: Aphididae) from India *Cytologia* **55** 231–241

KULKARNI P P 1984 chromosomes of seven species of aphids (Homoptera: Aphididae) *Bull Zool Surv Ind* **6** 267–270

KULKARNI P P & KACKER R K 1979 Chromosomes of four species of aphids (Homoptera: Aphididae) *Bull Zool Surv Ind* **2** 1–2

KULKARNI P P & KACKER R K 1980 Chromosomes of five species of aphids (Homoptera: Aphididae) *Bull Zool Surv Ind* **3** 103–105

KULKARNI P P & KACKER R K 1981 Chromosomes of six species of aphids (Homoptera: Aphididae) *Bull Zool Surv Ind* **3** 249–251

KURL S P & CHAUHAN R S 1986 Chromosome number in eleven species of aphids (Homoptera: Aphididae) hitherto unknown to cytology In *Proceedings of the 2nd National symposium on recent trends in aphidological studies* pp183–189

KUMARI M, KUMARI S & YADAV M 2022 Karyotypic studies on four aphid species of some common plant from Kangra Himachal Pradesh *Bull Pure Appl Sci Zool* **41** 101–105

KUZNETSOVA V G & SHAPOSHNIKOV G K1973 The chromosome numbers of the aphids (Homoptera: Aphidinea) of the world fauna *Entomologicheskoe Obozrenie* **52** 116–135

PAGLIAI A M 1965 A new category of female in the life cycle of *Brevicoryne brassicae* The amphibasic females *Experientia* **21** 283

RIS H 1942 A cytological and experimental analysis of the meiotic behaviour of the univalent X chromosome in the bearberry aphid *Tamalia* (=*Phyllaphis*) *coweni* (Ckll) *J Exp Zool* **90** 267–330

ROBINSON A G & CHEN Y H1969a Cytotaxonomy of Aphididae *Canad J Zool* **47** 511–516

ROBINSON A G & CHEN Y H 1969b Observations on *Rhopalosiphum padi* and *R. fitchii* (Homoptera: Aphididae) in Manitoba *Canad Entomol* **101** 110–112

SAMKARIA R, BALA J & GAUTAM D C 2010 Karyotype studies on some commonly occurring aphid species *Nucleus* **53** 55–59

SHARMA S & GAUTAM D C 2019 Studies on the chromosomes of aphids from Berthin region of Bilaspur district of Himachal Pradesh *J Cytol Genet* **20** (NS) 73–81

SINGH R KUMARI M & GAUTAM D C 2021 Karyotypic study on four gall forming aphid species from Himachal Pradesh *J Cytol Genet* **22** (NS) 63–66

Journal of Cytology and Genetics 2024 VOL. **25** (NS): 15−19

RESEARCH ARTICLE

HEREDITY OF LEAF ORIENTATION IN ONION AND ITS RELATION TO BULB YIELD

B. B. MADALAGERI*, PRAVEEN NOOJIBAIL AND G. SHIVAKUMAR
Division of vegetable breeding, I & B seeds private limited, Bengaluru 560 060
*For correspondence. Email: madalageribb@gmail.com

(Received 7 December 2023, revised accepted 1 January 2024)

SUMMARY Diverse genotypes in leaf orientation were crossed with diverse CMS lines. Erect and drooping orientations were dominant over semi-erect type. Erect × Drooping interacted to give semi-erect type. There is no correlation between leaf type and yield in onion as the latter is dependent on other selection factors. Care is needed while handling white genotypes as white × white will not always give white progenies.

Keywords: Onion, *Allium cepa*, heredity, leaf orientation.

INTRODUCTION

Onion is a difficult crop to handle by the breeders because of its biannual nature, big genome and breeding behaviour (cross pollination). Many aspects of its genetics are not precisely known yet. In view of its economic importance to India and being cultivated on large scale and consumed by household every day, due importance towards thorough investigation is needed on all aspects of onion. Upright leaf orientation in corn (Duncan 1971), rice (Erik et al. 1999) and wheat (Joshi & Chand 2002) populations have given higher yields. Should we consider it as universal phenomena as an index of selection is a question mark! On working with onion breeding and handling with population of vast variation, we wanted to verify the hypothesis of erect leaves related to yield in case of onion and this hypothesis does not hold good for onion as correlations did not establish the relationship. There is no study in onion concerning leaf orientation and its influence on bulb yield. Our study aimed at finding out heredity of leaf orientation in onion and its impact on bulb yield using diverse genotypes with different leaf orientations and how it is inherited to offsprings and whether we can make use of it in breeding programme to enhance the yield and quality of onion.

MATERIAL AND METHODS

Three male sterile lines (CMS) having different colours and leaf orientation were crossed to 9 male lines (Table 1, Figs 1–3). The seeds of 27 hybrids thus obtained and of the parents were sown in the polyhouse nursery using protrays filled with sterile coco-peat. Fortyfive d old

TABLE 1: Inheritance of leaf orientation in onion.

Genotypes (R lines)		CMS line (A lines)		
		16/17 DBT A (Red) SE	16/2 A (White) E	16/15 F4 Y A (Yellow) D
		F_1 Progeny		
Red				
1. 16/77 GR2 OOH-1	E	E	E	SE
2. 16/25 GR3 OOH MASS	E	E	E	SE
3. 16/26-1-1C GEN OOH	E	E	E	SE
White				
4. 16/47 TSS18 SPS	SE	SE	E	D
5. 17/R41-1W	SE	SE	E	D
6. 16/16 F4 W TSS17	SE	SE	E	SE
Yellow				
7. 16/7Y G1 T1 MASS	D	D	SE	D
8. 16/7Y G1 T4 GP2	D	D	SE	D
9. 16/7Y GR3 OOH	D	D	SE	D

E, Erect; SE, Semi-erect; D, Drooping.

TABLE 2: Inheritance of bulb colour in onion.

Genotypes (R lines)	CMS line (A lines)		
	16/17 DBT A (Red)	16/2 A (White)	16/15 F4 Y A (Yellow)
		F_1 Progeny	
Red			
1. 16/77 GR2 OOH-1	R	LR	R
2. 16/25 GR3 OOH MASS	R	LR	R
3. 16/26-1-1C GEN OOH	R	LR	R
White			
4. 16/47 TSS18 SPS	LR	LR	LR
5. 17/R41-1W	W	W	W
6. 16/16 F4 W TSS17	LR	W	LR
Yellow			
7. 16/7Y G1 T1 MASS	R	LR	Y
8. 16/7Y G1 T4 GP2	R	LR	Y
9. 16/7Y GR3 OOH	R	LR	Y

R, Red; LR, Light red; W, White; Y, Yellow; R lines, Restorer lines.

TABLE 3: Yield (g/bulb) and heterosis (%) over mid parent.

Genotypes (R lines)	YPB	CMS line (A lines)					
		16/17 DBT A (Red)		16/2 A (White)		16/15 F4 Y A (Yellow)	
		YPB	H	YPB	H	YPB	H
		128.6		111.5		186.8	
		F_1 Progeny					
Red							
1. 16/77 GR2 OOH-1	129.6	134.9	4.4	134.3	11.3	130.8	−17.3
2. 16/25 GR3 OOH MASS	157.7	149.7	4.5	158.8	17.9	182.2	5.7
3. 16/26-1-1C GEN OOH	144.2	123.9	−9.1	127.3	−0.4	170.0	2.7
Mean	143.9	136.4		140.2		161.0	
White							
4. 16/47 TSS18 SPS	120.4	123.3	−0.9	108.9	−6.1	121.9	−20.6
5. 17/R41-1W	176.8	108.2	−29.1	156.1	8.2	171.5	¯5.6
6. 16/16 F4 W TSS17	137.0	139.7	5.1	116.2	−6.4	194.2	19.9
	144.8	123.8		127.1		165.2	
Yellow							
7. 16/7Y G1 T1 MASS	123.1	128.3	1.9	148.5	26.6	136.0	−12.2
8. 16/7Y G1 T4 GP2	134.8	136.9	3.9	136.9	11.2	137.5	−14.5
9. 16/7Y GR3 OOH	105.7	97.0	−17.2	120.1	10.6	120.0	−18.0
Mean	121.2	120.7		135.2		131.2	

YPB, Yield per bulb; H, % Heterosis; R lines, Restorer lines. # Correlation co efficient (r) between yield and leaf orientation = 0.139 NS.

Figs 1–3: Leaf orientation in onion. 1. Erect leaves. 2. Semi-erect leaves. 3. Drooping leaves.

seedlings were transplanted in the open field having red soil. The leaf orientation was recorded on 60 d old crop and bulbs were harvested after the crop was 90 d old. Bulb weight was recorded from 10 competitive bulbs and averaged to indicate yield/bulb in grams. Correlation between leaf orientation to bulb yield was worked out using weighted ranks to leaf orientation as E = 3, SE = 2 and D = 1.

OBSERVATIONS

When semi-erect (SE) type A line was crossed with erect (E) type restorer (R) line, this gave rise to E type offspring indicating that erectness is dominant over semi-erectness (Table 1). E × E parents resulted in E type offspring which is expected but when E type R lines were crossed with droopiness (D) type A line, this resulted in SE type offsprings indicating gene interaction. When D type R line was crossed with SE type A line, offsprings produced were of D type indicating dominance of D over SE. There is only one exception to these observations where in D type yellow line crossed with SE type white line, 16/16 F4 W TSS17 resulting in SE type offspring.

When red R lines were crossed to red A line the offsprings produced were red as expected but when crossed to white A line, the offsprings were light red (LR), but when crossed to yellow A line, the offsprings were red. Thus red is completely dominant over yellow. Interesting things were noticed when white R lines are crossed across different coloured A lines. With red A line, 2 of them gave rise to LR type of offsprings as expected but the genotype 17/R41-1W was exceptional. It gave white offsprings across different coloured A lines indicating that it has colour inhibiting dominant gene *I*. Combination of yellow R lines gave rise to red offsprings with red A line and LR offsprings with white A line and yellow offspring with yellow A line (Table 2).

There was only one hybrid (16/15 F4 Y A × 16/16 F4 W TSS17) that has out yielded (194.25 g/bulb) and crossed the parental limits (highest being 186.85 g/bulb) of yellow A line. The mean performance of hybrids in most of the cases were less than mean performance of their parents except with yellow A line which contributed good hybrid performance. In several cases there was negative heterosis over mid parent or low positive heterosis indicating that parents are not good combiners (Table 3). The correlation between yield and leaf orientation was not significant (r = 0.139) suggesting that in onion, leaf orientation cannot be taken as a selection index for yield.

DISCUSSION

Onions have different types of leaf orientation. A yellow genotype with drooping leaves had the highest bulb weight as compared to any other genotype. We found that both erect and droopiness are dominant over semi-erect stature and this is a valuable guide to the breeder to select proper genotype via his breeding programme. Regarding bulb colour, one has to be careful about handling white genotype as it is a hidden character governed by dominant inhibiter gene in many cases. White was a colour diluter of red pigment resulting in light red-coloured bulbs in the progeny. Therefore, breeder aiming at dark

red colour progeny has to select both red-coloured parents (both A and R lines have to be red in a hybrid programme). The high yield advantage in onion was possible when both parents were in F_4 generations indicating that certain amount of heterozygosity in the parents is essential to get hybrid vigour.

In onion, erect and drooping leaf types are inherited as dominant factors. The interaction of these factors results in semi-erect leaf type. There was no relation between leaf orientation and the yield and hence, the former cannot be taken as a selection index.

REFERENCES

DUNCAN W G 1971 Leaf angle leaf area and canopy photosynthesis *Crop Sci* **11** 482–485

ERIC H M, YI-ZHU CHEN, STELLA HUBBART, SHAOBING PENG & PETER HORTON 1999 Interactions between senescence and leaf orientation determine in situ patterns of photosynthesis and photoinhibition in field grown rice *Plant Physiol* **119** 553–564

JOSHI A K & CHAND R 2002 Variation and inheritance of leaf angle and its association with spot blotch (*Bipolaris sorokiniana*) severity in wheat (*Triticum aestivum) Euphytica* **124** 283–291