

## Chromosomal Sex determination in dioecious Angiosperms - a review.

Ajanta Datta, Part time Lecturer, PG Department of Zoology, A.B.N. Seal College & Research Scholar, Panchanan Burma University, Coochbehar- 736101

Dipayan Chattopadhyay, Associate professor, PG Department of Botany, Bethune College, Kolkata- 700006

### Abstract :

The present review deals with the compilation of the different reports regarding the chromosomal sex determination mechanism in dioecious angiosperms. Although there is widespread unisexuality in higher plants, only a few species have well defined heteromorphic sex chromosomes; heterogamety being present either on the female or on the male side. In heteromorphic types, in majority of cases, Y chromosome is generally longer than X chromosome and autosomes and the male tendency of Y is stronger than the female tendency of X chromosome.

**Keywords :** Sex determination, X and Y chromosome, dioecious angiosperms.

In angiosperms, approximately 6% or 14600 species in 960 genera and 200 families are dioecious. Sex chromosomes in land plants are known from 48 species in 20 families of Liverworts, Gymnosperms and Angiosperms, where they evolved independently and over widely different time spans (Ming *et al.*, 2011). So far heteromorphic sex chromosomes are reliably known from 20 species of Cannabinaceae, Caryophyllaceae, Cucurbitaceae and Polygonaceae.

The literature contains many reports highlighting the use of molecular markers such as RAPD, RFLP, AFLP, SSR, SCAR and others for gender identification in higher plants (Datta *et al.*, 2017)

Among the living angiospermic species (3,00,000 approx), atleast 40 species in 21 genera from 16 families have cytogenetic and/or molecular evidence for the presence of sex chromosomes and many more species with sex chromosomes remain to be discovered. Among the 40 species, 20 species in 5 families have heteromorphic sex chromosomes, whereas the other 20 species in 13 families have homomorphic sex chromosomes. All known homomorphic sex chromosomes in land plants are angiosperms, and of these only 20 species in 6 genera namely, *Silene*, *Coccinia*, *Rumex*, *Trichosanthes*, *Cannabis* and *Humulus* have heteromorphic sex chromosomes.

All dioecious species have sex chromosomes, which carry genes that control development of males and females a separate individuals. Autosomes participate in sex organ developmental pathways (Charlesworth 2012). Sex chromosomes are linkage groups like autosomes, except that they specify inheritance of sex. Only in a small number of plant species, the sex chromosomes are morphologically distinguishable in terms of size. The nondistinguishable sex chromosomes are called homomorphic.

A pivotal event in sex chromosome evolution is the suppression of recombination between the two sex determinant genes (Ming *et al.*, 2011)

Sex chromosomes of plants were first described in white campion and hop, Sorrel and *Elodia*. Heteromorphic sex chromosomes have been convincingly demonstrated in species of four families (Charlesworth and Guttman, 1999; Matsunaga and Kawano, 2001). Among the species with heteromorphic sex chromosomes, white campion has distinctive X and Y chromosomes, which are the largest and second largest chromosomes, respectively, in the male plants. Sorrel has one large X and a pair of different small Y chromosomes in male plants.

Among the species with homomorphic sex chromosomes, papaya has a clearly defined Male Specific Y (MSY) region, while *Asparagus* has an M locus with evidence of suppression of recombination. A female heterozygous sex chromosome system might exist among *Fragaria* species in Rosaceae (Kihara, 1930).

In *Silene latifolia* (formerly *Melandrium album*) of the family Caryophyllaceae, the Y chromosome is decisive in determining sex because it was observed that, the presence of a single Y chromosome can suppress female development when three X chromosomes are present, moreover application of hormones does not convert the sex and autosome ratios have no effect on the sex determining factors on the Y chromosome (Westergaard, 1958). It can also be said that, as in true in mammals, the sex of the individual is determined entirely by the presence or absence of the Y chromosome, which is called the active-Y system.

In *Rumex acetosa* (sorrel) of family Polygonaceae, male plants have one X and two different Y chromosomes ( $2n=15, XY_1Y_2$ ), and females have two X chromosomes ( $2n=14, XX$ ). The two Y chromosomes are highly heterochromatic. Both Y chromosomes in sorrel are required for pollen fertility but not for stamen development. In contrast to *Silene latifolia*, Y chromosomes in *Rumex acetosa* do not suppress female gynoecium development and do not contain male determining genes, because plants with  $2A + 2X + 1Y$  or  $2Y$  were females. Instead of an active-Y system, sorrel sex is determined by an X-autosome balance system.

In *Coccinia indica*, of the family Cucurbitaceae (which is an important example of X/Y heteromorphism), the Y chromosome is 2.06 times larger than the largest autosome and much more larger than the X chromosome (Roy and Roy, 1971; Chattopadhyay and Sharma, 1991).

In this study, we have reported a list of different unisexual monoecious and dioecious angiospermic plant species where heteromorphic and homomorphic sex chromosomes were noted. The study also includes the list of some dioecious angiosperms where sex chromosomes were reported to be absent (Table 1-4).

Table 1 : List of Angiospermic plant species with heteromorphic sex chromosome

FAMILY	SPECIES	2n chromosome number female : male	Female sex chromosome	Male sex chromosome	References
Cannabinaceae	<i>Cannabis sativa</i>	20	XX	XY	Chattopadhyay, 1991 ; Yamada, 1943 ; Sakamoto et al. 1995, 1998,2000,2005
	<i>Humulus lupulus</i>	20	XX	XY	Jacobson, 1957 ; Sinoto, 1929 ; Winge, 1932 ; Ono, 1955 ; Polley, 1997 ;
	<i>Humulus lupulus</i> var. <i>cordifolius</i>	20	$X_1X_1X_2X_2$	$X_1Y_1X_2Y_2$	Nakajima , 1937 ; Ono, 1937
	<i>Humulus japonicus</i>	20	XX	$XY_1Y_2$	Jacobson, 1957 ; Danilova, & Karlov, 2006 ; Kihara, 1929 ; Kihara & Hirayoshi, 1932
	<i>Cannabis indica</i>	20	XX	XY	Mandolino et. al., 1999
	<i>Cannabis ruderalis</i>	20	XX		Peil et. al., 2003 ; Diggle et. al., 2011
	<i>Humulus lupulus</i> var. <i>cordiflorus</i>	40	$X_1X_1X_2X_2$	$X_1Y_1X_2Y_2$	Seefelder et. al. 2000 ; Karlov, 2003
	<i>Humulus yunnanensis</i>	20	XX	$XY_1Y_2$	Grabowska. Joachimiak et.al, 2006, 2011
	<i>Humulus acetosa</i>				

Polygonaceae	Collective Genus - <b>Rumex</b> Taxon : <b>Acetosella</b>				
	<i>angiocarpa</i>	20	XX	XY	Love, 1967 ; Pazourkoa, 1966
	<i>tenuifolia</i>	28	XXXX	XXXY	Love, 1957, 1967
	<i>vulgaris</i>	42	XXXXXX	XXXXX Y	Gadella & Kliphuis, 1966 ; Jensen, 1926 ; Johnson & Briggs, 1962 ; Kihara, 1925 ; Ono, 1935
	<i>graminifolia</i>	48	XXXXXX XX	XXXXX XXY	Love, 1943 ; Jhukova, 1968
	<i>Rumex acetosa</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Kihara & Ono, 1923 ; Kurita & Kuroki, 1970
	<i>R. papillaris</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Bartkowika, 1971
	<i>R. intermedius</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Rejon et. al, 1994
	<i>R. thyrsiflorus</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Shibata et. al., 1999, 2000
	<i>R. rothschildinus</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Rahman & Ainsworth, 2004
	<i>R. suffruticosus</i>	16	XX	XY	Rahman & Ainsworth, 2004
	<i>R. acetocella</i>	14	XX	XY	Stehlik & Blattner, 2004
	<i>R. hastatulus</i>	14 : 14/15	XX	XY / XY <sub>1</sub> Y <sub>2</sub>	Navajas – Perez et.al., 2005 a,b, 2006, 2009 ; Cunado et. al. 2007 ; Blocka – Wandas wt. al., 2007 ; Mariotti et. al., 2009 ; Steflova et. al., 2013
	Taxon : <b>Acetosa</b> <b>Sectio Acetosa</b> <b>Subsectio Acetosa</b>				
	<i>gussonei</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Love, 1967
	<i>intermedia</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Love, 1967
	<i>pratensis</i> , <i>ssp. pratensis</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Kihara & Ono, 1925 ; Kihara & Yamamoto, 1932 ; Love, 1967 ; Ono, 1935 ; Sato & Sinotu, 1935 ; Shimizu, 1961 ; Sinoto, 1929
	<i>ssp. alpestris</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Kihara & Yamamoto, 1932 ; Love 1967 ; Ono, 1935 ; Takenaka, 1930 ; Zuk, 1963
	<i>ssp. ambigua</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Love, 1967
	<i>ssp. amplexicaulis</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Love, 1967
	<i>ssp. nivalis</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Love, 1967
	<i>ssp. papillaris</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Love, 1967
	<i>ssp. Pseudoxyria</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Zhukova, 1968
	<i>ssp. serpentinicola</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Laane, 1965
	<i>thyrsiflora</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Laane, 1965 ; Love, 1967 ; Meurman, 1925 ; Lux, 1963
	<i>thyroides</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Love, 1967
	<i>tuberosa</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Love, 1967
	<i>ssp. tuberosa</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Love, 1967
	<i>ssp. contracta</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Love, 1967
	<i>ssp. cretica</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Love, 1967

	<i>ssp. cretica</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Love, 1967
	<i>ssp. horizontalis</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Love, 1967
	<i>ssp. turcomanica</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Love, 1967
	<b>Subsectio Americanae</b>			XY <sub>1</sub> Y <sub>2</sub>	
	<i>hustatua</i>	8 : 9	XX	XY <sub>1</sub> Y <sub>2</sub>	Jackson, 1967 ; Patil, 1967 ; Smith, 1958, 1963, 1967 a, Smith & Smith, 1947
	<b>Subsectio Insectivalves</b>			XY <sub>1</sub> Y <sub>2</sub>	
	<i>rothschildiana</i>	14 : 15	XX	XY <sub>1</sub> Y <sub>2</sub>	Patil, 1967 ; Smith & Smith, 1947
	<b>Sectio Paucifoliae</b>				
	<i>gracilescens</i>	14	XX	XY	Smith, 1967 a,b
	<i>Paucifolia</i>	28	XXXX	XXXXY	Love & Sarkar, 1956 ; Smith, 1967 a,b
Cariophyllaceae	<i>Silene latifolia</i>	24	XX	XY	Donnison et. al., 1996 ; Di – Stilio et. al., 1998 ; Zhang et. al., 1998 ; Siroky et. al., 2001 ; Lengerova et. al., 2003, 2004 ; Moore et. al., 2003 ; Smith, 1964 ; Nicolas et. al., 2005 ; Zluvova et. al., 2005, 2007 ; Hobza et. al.m 2006 ; Bergero et/ al. 2007 ; Steven et. al., 2007 ; Mrackova et. al., 2008
	<i>S. dioica</i>	24	XX	XY	Marais et. al., 2008, 2011
	<i>S. marizii</i>	24	XX	XY	Rautenberg et. al., 2012
	<i>S. buffelii</i>	24	XX	XY	Howell et. al., 2009 a,b
	<i>S. diclinis</i>	24 : 25	XX	XY <sub>1</sub> Y <sub>2</sub>	Delph et. al., 2010 ; Nishiyama et. al., 2010 ; Diggle et. al., 2011 ; Kafer et. al., 2013
Cucurbitaceae	<i>Coccinia indica</i>	24	XX	XY	Bhaduri & Bose, 1947 ; Kumar & Vishveshwaraiah, 1952 ; Roy & Roy, 1971 ; Diggle et. al., 2011 ; Holstein & Renner, 2011 ; Holstein, 2012 ; Sausa et. al., 2013
Menispermaceae	<i>Tiliacora racemosa</i>	26	XX	XY	Chattopadhyay & Sharma, 1991

Table 2 : List of Angiospermic plant species with homomorphic sex chromosome\*\*

FAMILY	SPECIES	2n chromosome number <b>female :</b> <b>male</b>	Female sex chromosome	Male sex chromosome	References
Caryophyllaceae	<i>Silene colpophylla</i>	24	XX	XY	Charlesworth & Guttman, 1999
	<i>S. otites</i>	24	WZ	ZZ	Charlesworth & Guttman, 1999
	<i>S. wolgensis</i>				Charlesworth & Guttman, 1999
Amaranthaceae	<i>Spinacea oleracea</i>	12	XX	XY	Murray, 1940
	<i>Atriplex garrettii</i>	18	XX	XY	Bemis & Wilson, 1953 ; Freeman et. al., 1994 ; Ruas et. al., 1998
	<i>Acnida tamariscina</i>	32	XX	XY	Khattak et. al., 2006 ; Lan et. al., 2006 ; Diggle et. al., 2011 ; Ming et. al., 2011 ; Onodera et. al., 2011
Cucurbitaceae	<i>Bryonia dioica</i>	20	XX	XY	Charlesworth & Guttman, 1999 ; Volj & Renner, 2008 ; Oyama et. al., 2009, 2010
	<i>Ecballium elaterium</i>	18	XX	XY	Galan, 1946 ; Westergaard, 1958 ; Costich & Meagher, 1992
	<i>Trichosanthes dioica</i>	22	XX	XY	Patel, 1952 ; Kumar et. al., 2008
	<i>T. kirilowi</i>	22			
	<i>T. japonica</i>	22			
	<i>T. multiloba</i>	22			
	<i>T. ovigera</i>	22			
	<i>T. cucumervides</i>	22			
Piperaceae	<i>Piper longum</i>	52			Banerjee et. al., 1999 ; Manoj et. al., 2005
Myristicaceae	<i>Myristica fragrans</i>	24			Shibu et. al., 2000
Dioscoreaceae	<i>Dioscorea tokoro</i>	20	XX	XY	Martin, 1966
	<i>D. floribunda</i>	40	XXXX	XXYY	Terauchi & Kahl, 1999 ; Diggle et. al., 2011
Asparagaceae	<i>Asparagus officinalis</i>	20	XX	XY	Loptien, 1979 ; Biffi et. al., 1995 ; Jiang & Sink, 1997 ; Reamon-Buttner et. al., 1998 ; Spada et. al., 1998 ; Gao et. al., 2007 ; Ming et. al., 2011 ; Deng et. al., 2012

Araceae	<i>Phoenix dactylifera</i>	36	XX	XY	Siljak-Yakovlev, 1996 ; younis et. al., 2008 ; Al-Dous et. al., 2011 ; Diggle et. al., 2011 ; Al-Mahmoud et. al., 2012
	<i>P. rupicola</i>	36			Al-Mahmoud et. al., 2012 ; Cherif et. al., 2013 ; Rai & Singh, 2013
	<i>Borassus flabillifer</i>	32			George et. al., 2007
Poaceae	<i>Poa trivialis</i>	56			Renganayaki et. al., 2005
	<i>Distichlis spicata</i>	26			Eppley et. al., 1998
	<i>Buchloe dactyloides</i>	36	XX	XY	Zhou, 2011
Proteaceae	<i>Leucodendron xanthocomus</i>	26	XX	XY	Harris & Pannell, 2010 ; Midgley, 2010
Vitaceae	<i>Vitis vinifera</i>	38	XX	XY	Costantini et. al., 2008 ; Marguerit et. al., 2009
Rosaceae	<i>Fragaria virginiana</i>	56	WZ	ZZ	Ahmadi & Bringhurst, 1991 ; Ashman, 2003
	<i>F. chiloensis</i>	56	WZ	ZZ	Spigler et. al., 2008, 2010, 2011
	<i>F. elatior</i>	21	WZ	ZZ	Spigler et. al., 2008, 2010, 2011
	<i>F. muschata</i>	42	WZ	ZZ	Golberg et. al., 2010 ; Diggle et. al., 2011
Elaeagnaceae	<i>Hippophae rhamnoides</i>	24 : 22			Persson & Nybom, 1998 ; Sharma et. al., 2010
Moraceae	<i>Ficus fulva</i>	28			Tracey et. al., 2004
Datisceae	<i>Datisco cannabina</i>	22	WZ	ZZ	Wolf et. al., 2001 ; Diggle et. al., 2011
Euphorbiaceae	<i>Marcurialis annua</i>	16	XX	XY	Pannell, 1997 a,b , 2008 ; Yang et. al., 1998 ; Khadka et. al., 2002, 2005 ; Pannell et. al., 2004 ; Obbard et. al., 2006 ; Elze & Pannell, 2011 ; Sanchez-Vilas et. al., 2011 ; Mwase et. al., 2007
Salicaceae	<i>Populus trichocarpa</i>	38	WZ	ZZ	Paolucci et. al., 2008 ; Yin et. al., 2008
	<i>P. tremuloides</i>	38	XX	XY	Hou et. al., 2009
	<i>P. alba</i>	38			Pakull et. al., 2009
	<i>P. tomentosa</i>	38			Tuskan et. al., 2012
	<i>Salix viminalis</i>	38	WZ	ZZ	Alstron-Rapaport et. al., 1998 ; Gunter et. al., 2003 ; Semerikov et. al., 2003 ; Yin et. al., 2008 ; Diggle et. al., 2011 ; Samantaray et. al., 2010

Caricaceae	<i>Carica papaya</i>	18	XX	XY	Hofmeyr, 1938 ; Sondur et. al., 1996 ; Paranis et. al., 1999, 2000 ; Deputy et. al., 2002 ; Urasaki et. al., 2002 ; Liu et al., 2004 ; Ma et. al., 2004 ; Chen et. al., 2007 ; Gangopadhyay et. al., 2007 ; Ming et. al., 2008 ; Yu et. al., 2008 a,b ; Wai et. al., 2010 ; Wu et. al., 2010 ; Gschwend et. al., 2012
	<i>Vasconcellea geudotinana</i>	18	XX	XY	Horovitz & Jimenez, 1967 ; Wu et. al., 2010
	<i>V. parviflora</i>	18	XX	XY	Horovitz & Jimenez, 1967 ; Wu et. al., 2010
	<i>V. trioecious</i>	18	XX	XY	Horovitz & Jimenez, 1967 ; Wu et. al., 2010
	<i>V. pulchera</i>	18	XX	XY	Horovitz & Jimenez, 1967 ; Wu et. al., 2010
	<i>V. cundinamarce nsis</i>	18	XX	XY	Horovitz & Jimenez, 1967 ; Wu et. al., 2010

\*\* Some spaces are empty in some species where the required information is not found

<b>Table: 3 Some other previous reports of presence of Sex chromosomes in plants</b>	
<b>Species</b>	<b>Refernces</b>
Salicaceae	
<i>Salix</i>	Present: BLACKBURN & HARRISON 1924; ERLANSON & HERMANN 1927; HESLOP-HARRISON 1926; MEURMAN 1925; NAKAJIMA 1937,1942; SINOTO 1929; SUTO 1944 Absent:HAKANSSON 1938; JOHNSON 1940; MUNTZING 1936; PETO 1938; WILKINSSON 1944
Moraceae	MUNTZING 1936; PETO 1938; WILKINSSON 1944
<i>Cudrania triloba</i> HANCE	SINOTO 1929
<i>Morus bombycis</i> KOIDZ	SINOTO 1929
Urticaceae	
<i>Urtica dioica</i> L.	MEURMAN 1925 (doubtful cf. A. and D. LOVE 1942)
Santalaceae	
<i>Buckleya joan</i> MAKINO	NAKAJIMA 1937
Loranthaceae	
<i>Phoradendron flavescens</i> NUTT	BILLINGS 1932, 1933 (female: 2A, male: 2A +X)
<i>P. villosum</i> NUTT.	BILLINGS 1932, 1933
Chenopodiaceae	
<i>Atriplex hymenelytra</i> (TORR.) WATS.	BILLINGS 1934 (female: 2A, + X <sub>1</sub> X <sub>1</sub> X <sub>2</sub> X <sub>2</sub> , male: 2A- X <sub>1</sub> X <sub>2</sub> Y)
<i>Spinacia tetrandra</i> STEV	ARARATJAN 1939
<i>Spinacia oleracea</i> L.	Present: ZOSCHKE 1956 Absent: ARARATJAN 1939; BEMIS & WILSON 1953 HAGA 1935
Caryophyllaceae	
<i>Silene otites</i> SM.	FAVARGER 1946
<i>Silene densiflora</i>	FAVARGER 1946
Cercidiphyllaceae	
<i>Cercidiphyllum japonicum</i>	NAKAJIMA 1942
Menispermceae	
<i>Cocculus trilobus</i> (THUNB.)DC.	NAKAJIMA 1937
<i>Stephania rotunda</i> LOUR.	MATHEW 1958
<i>Cissampelos pareira</i> L.	MATHEW 1958
Rosaceae	
<i>Fragaria elatior</i> EHRB	KIHARA 1930 (female: XY, male: XX)
Rutaceae	
<i>Zanthoxylum piperitum</i> DC.	SINOTO 1929; NAKAJIMA 1937
Daphniphyllaceae	
<i>Daphniphyllum macropodium</i> MIQ	SINOTO 1929
Aquifoliaceae	
<i>Ilex serrata</i>	NAKAJIMA 1942
Aceraceae	
<i>Acer negunda</i>	Present : SINOTO 1929 Absent : FOSTER 1933
Simarubaceae	

<i>Picrassima quassioides</i>	NAKAJIMA 1942
Dilleniaceae	
<i>Actinidia kolomicta</i>	NAKAJIMA 1942
<i>Actinidia polygama</i>	NAKAJIMA 1942
Theaceae	
<i>Eurreya japonica</i>	NAKAJIMA 1942
Datisceae	
<i>Datisca cannabina</i>	SINOTO 1929
Valerianaceae	
<i>Valeriana dioica</i>	MEURMAN 1925
Cucurbitaceae	
<i>Trichosanthes cucumeroides</i>	NAKAJIMA 1937
MAXIM	
<i>T.japonica</i>	NAKAJIMA 1937
<i>T.dioica</i> ROXB	PATEL1952; SARKAR & DATTA 1987,1988
<i>T.multiloba</i> MIQ	KURITA 1939
Hydrocharitaceae	
<i>Elodea canadensis</i>	SANTOS 1924
<i>Elodea gigantea</i>	SANTOS 1923
<i>Hydrilla verticillata</i>	SINOTO 1929
Palmae	
<i>Trachycarpus excelus</i> WENDL	SINOTO 1929
<i>Trachycarpus fortunei</i>	SINOTO 1929
<i>Borassus flabellifer</i> L.	SARKAR 1956
<i>Phoenix sylvestris</i> ROXB.	SARKAR 1956
<i>Phoenix rupicola</i> T. ANDERS.	SARKAR 1956
Liliaceae	
<i>smilax</i> sp.	Present: NAKAJIMA 1937,1942
	Absent: LINDSAY 1930
Dioscoreaceae	
<i>Dioscorea sinuata</i> VELL.	MEURMAN 1925(female: XX, male: XO)
<i>D. elata</i> L.	SMITH 1937(female: XX, male: XO)
<i>D. reticulata</i> GAY	SMITH 1937(female: XX, male: XO)
<i>D. macroura</i> HARMS	SMITH 1937(female: XX, male: XY)
<i>D. discolor</i> KUNTH	SMITH 1937(female: XX, male: XY)
<i>D. fargessii</i> FRANCH	SMITH 1937(female: XX, male: XY)
<i>D. gracillima</i> MIQ	NAKAJIMA 1937(female: XX, male: XY)
<i>D. tokoro</i> MAKINO	NAKAJIMA 1937(female: XX, male: XY)
<i>D. japonica</i> THUNB	NAKAJIMA 1937(female: XX, male: XY)
<i>D. tomentosa</i> KOEING ex ROXB	RAMCHANDRAN 1962(female: XX, male: XY)
<i>D. pentaphylla</i> L.	RAMCHANDRAN 1962(female: XX, male: XY)
<i>D. bulbifera</i> L.	RAMCHANDRAN 1962(female: XX, male: XY)
<i>D. spinosa</i> ROXB. ex WALL	RAMCHANDRAN 1962(female: XX, male: XY)

**Table 4: Some reports on the dioecious Angiosperms where Sex chromosomes are absent**

Species	References
Garryaceae	
<i>Garrya elliptica</i> DOUGL.	MEURMAN 1930
Myricaceae	
<i>Myrica carolinensis</i> MILL.	STOKES 1937
<i>M. cerifera</i> L.	STOKES 1937
<i>M. pumila</i> (MICHX) SMALL	STOKES 1937
<i>M. nagi</i> THUNB	SUGIURA 1927
( <i>M. rubra</i> S. et Z..)	
Loranthaceae	
<i>Arceuthobium axycedri</i> (DC.) M.B.	PISEK 1924
<i>Viscum album</i> L.	PISEK 1923;
	STEINDL 1935
Amaranthaceae	
<i>Acnida tuberculata</i> MOQ	MCWILLIAMS 1930
Chenopodiaceae	
<i>Atriplex babingtonii</i> WOODS	WULFF 1937
Caryophyllaceae	
<i>Silene roemerii</i> FRIVALD	SCHATZ (reported by CORRENS 1928)
Ranunculaceae	
<i>Clematis heracleaefolia</i> DC.	NAKAJIMA 1937
<i>C. virginiana</i> L.	LINDSAY 1929, 1930
<i>Thalictrum fendleri</i> ENGELM	KUTHN 1928, 1930a,b
Menispermaceae	
<i>Cocculus villosus</i> DC.	CHATTOPADHYAY AND SHARMA 1991; JOSHI & RAO 1935;
	SHARMA & BHATTACHARYYA 1955
<i>Menispermum canadense</i> L.	LINDSAY 1929, 1930
<i>Tinospora cordifolia</i> MIERS	CHATTOPADHYAY AND SHARMA 1991; JOSHI & RAO 1935;
	SHARMA & BHATTACHARYYA 1955
<i>Tinospora tomentosa</i> MIERS	CHATTOPADHYAY AND SHARMA 1991
<i>Stephania hernandifolia</i> WALP.	CHATTOPADHYAY AND SHARMA 1991
	SHARMA & BHATTACHARYYA 1955
Saxifragaceae	
<i>Ribes alpinum</i> L.	MEURMAN 1925
<i>R. orientale</i> DESF.	MEURMAN 1928
<i>R. saxatile</i> PALI	MEURMAN 1928
Euphorbiaceae	
<i>Mercurialis aniuia</i> L.	SZTAJGERWADOWNA 1929;
	YAMAPOLSKY 1925
<i>Putranjiva roxburghii</i>	CHATTOPADHYAY & SHARMA 1991
<i>Trewia nudiflora</i> L.	MUKHERJEE 1974
Flacourtiaceae	
<i>Flacourtia ramontchi</i> L.	MUKHERJEE 1974
<i>F. sepiaria</i> ROXB.	MUKHERJEE 1974
Vitaceae	
<i>Vitis cinerea</i> ENGELM	KOBEL 1929

<i>V. ruperstris</i> SCHEELE var. <i>metallica</i>	KOBEL 1929
<i>V. vinifera</i> L.	KOBEL 1929
Malvaceae	
<i>Napaea aioica</i> L.	BUNTEN 1929
Caricaceae	
<i>Carica papaya</i> L.	DATTA 1971; LINDSAY 1930
Eleagnaceae	
<i>Shepherdia canadensis</i> (L.) NUTT	COOPER 1932
Umbelliferae	
<i>Trinla hispida</i> HOFFM ( <i>T. hoffmanni</i> BIES.)	ARARATJAN 1939
Cornaceae	
<i>Aucuba chinensis</i> BENTH.	KIHARA & YAMAMOTO 1935
<i>A. japonica</i> THUNB	MEURMAN 1929; SINOTO 1929; DSUGIURA 1927; YAMAMOTO 1937
Cucurbitaceae	
<i>Bryonia dioica</i> JACQ.	LINDSAY 1929, 1930 ; MEURMAN 1925
<i>Luffa echinata</i> ADANS.	DUTTA & ROY 1982
<i>Memordica dioica</i> L.	RICHHARIA & GHOSH 1953; ROY et al. 1966 TRIVEDI & ROY 1972
<i>Edgaria darjeelingensis</i> CLARKE	THAKUR et al. 1969 THAKUR & SINHA 1972-1973
<i>Melothria heterophylla</i> L.	ROY 1970; SINGH 1972
<i>Trichosanthes lepiniana</i> (NAUD.) COGN.	PANDEY & SARAN 1986
Najadaceae	
<i>Najas marina</i> L.( <i>N. major</i> ALL.)	TAKAMINE 1927; WINGE 1927
Hydrocharitaceae	
<i>Hydrocharis morsus-ranae</i> L.	TUSCHNJAKOWA 1929
<i>Vallisneria gigantea</i> GRAEBN	JORGENSEN 1927
<i>V. spiralls</i> L.	JORGENSEN 1927;WINGE 1927
Cyperceae	
<i>Carex grillatoria</i> MAXIM.	NAKAJIMA 1937
Palmae	
<i>Phoenix canariensis</i> HORT.	BEAL 1937
<i>P. dactylifera</i> L.	BEAL 1937
Liliaceae	
<i>Asparagus ojjicinalis</i> L.	FLORY 1932; SHORI & NAKAMURA 1928
<i>Smilax herbaceae</i> L.	ELKINS 1914; LINDSAY 1929,1930
Dioscoreaceae	
<i>Dioscorea caucasica</i> LIPSKY	MEURMAN 1925
<i>D. quaternata</i> (HEMSL.) J.F.GMEL	JENSEN 1937
<i>D. composita</i> HEMS L	MARTIN & ORTIZ 1963
<i>D. floribunda</i> MART. et GAL	MARTIN & ORTIZ 1963
<i>D. friedrichsthalii</i> R.KUNTH	MARTIN & ORTIZ 1963
<i>D. spiculiflora</i>	MARTIN & ORTIZ 1963

### Conclusion:

According to Ming *et al.* 2007, “Unisexual species have sex determination mechanisms ranging from genetic to environmental, but genetic factors play far greater roles. Genetic mechanisms range from a single locus on an autosome to heteromorphic sex chromosomes containing multiple genes involved in sex determination. Chromosomal sex determination systems may be an evolutionary consequence of natural selection in favour of dioecy. Sex chromosomes do not appear suddenly in animals or plants. Rather, it is the pair of autosomes bearing the sex determination genes that have evolved specialised features, i.e. the degeneration of the Y chromosome, resulting in heteromorphy that became the hall mark of sex chromosomes”.

### Acknowledgement:

The authors wish to thank DST-FIST for providing infrastructural help in the department.

Authors are also grateful to Smt. Debarati Roy and Smt. Ananya Mukherjee for preparation the manuscript of the paper.

### References:

- Ahmadi, H. and Bringham, R. (1991). “Genetics of Sex Expression in *Fragaria* species”. *Am. J. Bot.* 78:504- 514.
- Ainsworth, C.C., Lu, J., Winfield, M. and Parker, J.S. (1999). “Sex determination by X:autosome dosage: *Rumex acetosa* (sorrel). In C.C. Ainsworth[ed.], Sex determination in plants”. BIOS Scientific Publishers, Oxford. UK. 124-126
- Al-Dous, E., George, B., Al-Mahmoud, M. E., Al-Jaber, M. Y., Wang, H., Salameh, Y. M. et al. (2011). “De novo genome sequencing and comparative genomics of date palm (*Phoenix dactylifera*)”. *Nat. Biotech.* 29: 521–527.
- Alexandrov, O. S., Divashuk, M. G., Yakovin, N. A. and Karlov, G.I. (2012). “Sex chromosome differentiation in *Humulus japonicus* Siebold Zuccarini, 1846. (Cannabaceae) revealed by fluorescence in situ hybridization of sub-telomeric repeat”. *Comp. Cytogen.* 6: 239–247.
- Allen, C.E. (1940). “The genotypic basis of sex-expression in angiosperms”. *Bot. Rev.* 6:227-300
- Al-Mahmoud, M., Al-Dous, E. K., Al-Azwani, E. K. and Malel, J.A. (2012). “DNA based essays to distinguish date palm (Arecaceae) gender”. *Am. J. Bot.* 99: E7–E10.
- Alstron, R.C., Lascoux, M., Wang, Y.C., Roberts, G. and Tuskan, G.A. (1998). “Identification of RAPD marker linked to sex determination in the basket willow (*Salix viminalis* L.)”. *J. Hered.* 89: 44-49
- Alstron-Rapaport, C., Lascoux, M., Wang, Y. C., Roberts, G. and Tuskan, G.A. (1998). “Identification of RAPD marker linked to sex determination in the basket willow (*Salix viminalis* L.)”. *J. Hered.* 89: 44–49.
- Araratjan, A.G. (1939). “Heterochromosomes in the wild spinach”. *C.R. Acad. Sci. U.R.S.S.* 24: 56
- Ashman, T.L. (2005). “The limits of sexual dimorphism in vegetation traits in a gynodioecious plant”. *Am. Nat.* 166:s5- s16.
- Atanassov, I., Delichere, C., Filatov, D.A., Charlesworth, D., Negrutiu, I. and Moneger, F. (2001). “Analysis and evolution of two functional Y-linked loci in a plant sex chromosome system”. *Molecular Biology and Evolution* 18: 2162-2168
- Banerjee, N. S., Manoj, P. and Das, M. R. (1999). “Male-sex-associated RAPD markers in *Piper longum* L. Curr”. *Sci.* 77: 693–695.
- Barlow, B. A. and Weins, D. (1976). “Translocation heterozygosity and sex ratio in *Viscum fischeri*”. *Heredity* 37: 27–40.
- Bartkowiak, E. (1971). “Mechanism of sex determination in *Rumex hastatulus*-D”. *Theor. Appl. Genet.* 41: 320–326.
- Bemis, W. P. and Wilson, G. B. (1953). “A new hypothesis explaining the genetics of sex determination in *Spinacea oleracea*”. *L. J. Hered.* 44: 91–95.
- Bergero, R. and Charlesworth, D. (2011). “Preservation of Y- transcriptome in a 10-million-year-old plant sex chromosome system”. *Curr. Biol.* 21: 1470–1474.
- Bergero, R., Forrest, A., Kamau, E. and Charlesworth, D. (2007). “Evolutionary strata on the X-chromosome of the dioecious plan *Silene latifolia*: Evidence from new sex-linked genes”. *Genetics* 175 :1945–1954.
- Bhardwaj, M. and Eckert, C. G. (2001). “Functional analysis of synchronous dichogamy in flowering bush *Butomus umbellatus* (Butomaceae)”. *Am. J. Bot.* 88: 2204–2213.

- Biffi, R., Restivo, F. M. and Tassi, F. (1995). "A restriction fragment length polymorphism probe for early diagnosis of gender in *Asparagus officinalis* L". *Hortic. Sci.* 30: 1463–1464.
- Billings, F.H. (1934). "Male gametophyte of *Atriplex hymenelytra*". *Bot. Gaz* 95: 477-484
- Blackburn, K.B. (1923). "Sex chromosomes in plants". *Nature* 112: 687-688
- Blackburn, K.B., J.W Heslop-Harrison. (1924). "A preliminary account of the chromosomes and chromosome behavior in Saliaceae". *Ann. Bot.* 38: 361-378
- Blocka, W.M., Sliwinska, E., Grabowska, J.A., Musial, K. and Joachimiak, A.J. (2007). "Male gametophyte development of two different DNA classes of pollen grains in *Rumex acetosa* L., a plant with XX/XY<sub>1</sub>Y<sub>2</sub> sex chromosome system and a female-biased sex ratio". *Sex. Plant Reprod* 20:171-180
- Blocka-Wandas, M., Sliwinska, E., Grabowska-Joachimiak, A., Musial, K. and Joachimiak, A. J.(2007). "Male gametophyte development and two different DNA classes of pollen grains in *Rumex acetosa* L., a plant with an XX/XY<sub>1</sub>Y<sub>2</sub> sex chromosome system and a female-biased sex ratio". *Sex. Plant Reprod.* 20: 171– 180.
- Bull, J. J. (1983). "Evolution of sex determining mechanism, pp. 316". Benjamin-Cummings, Menlo Park, USA.
- Carroll, S. B. and Mulcahy, D. L. (1993). "Progeny sex ratios in dioecious *Silene latifolia* (Caryophyllaceae)". *Am. J. Bot.* 80: 551–556.
- Charlesworth, B. (2002). "Plant sex determination and sex chromosomes". *Heredity* 88: 94–101.
- Charlesworth, B. (1991). "The evolution of sex-chromosomes". *Science* 251: 1030–1033.
- Charlesworth, B. and Charlesworth, D. (1978a). "A model for the evolution of dioecy and gynodioecy". *Am. Nat.* 112: 975–997.
- Charlesworth, D. (1984). "Androdioecy and the evolution of dioecy". *Biol. J. Linn. Soc.* 22: 333–348.
- Charlesworth, D. (2012). "Plant sex chromosome evolution". *J. Exp. Bot.* 64: 405–420.
- Charlesworth, D. (2013). "Plant sex chromosome evolution". *J. Exp. Bot.* 64: 405–420.
- Charlesworth, D. and Charlesworth, B. (1978b). "Population genetics of partial male-sterility and the evolution of monoecy and dioecy". *Heredity* 41: 137–153.
- Charlesworth, D., and Guttman, D. (1999). "The evolution of dioecy and plant sex chromosome systems. In C. C. Ainsworth [ed.], *Sex determination in plants*, 25-49". BIOS Scientific Publishers, Oxford, UK.
- Charlesworth, D., Charlesworth, B. and Marais, G. (2005). "Steps in the evolution of heteromorphic sex chromosomes". *Heredity* 95: 118–128.
- Chattopadhyay, D. and Sharma, A.K., (1991). "Sex determination in dioecious species of plants". *Feddes Repert.* 102: 29-55.
- Chattopadhyay, D., Sharma, A.K. (1988). "Sex difference and chromosomes in *Putranjiva roxburghii* Wall.". *Curr. Sci.* 57: 1017-1019
- Chen, C. X., Yu, Q., Hou, S., Li, Y., Eustice, M., Skelton, R. L. *et al.* (2007). "Construction of a sequence-tagged high-density genetic map of papaya for comparative structural and evolutionary genomics in brassicales". *Genetics* 177:2481–2491.
- Chen, C.X., Yu, Q., Hou, S., Li, Y., Eustice, M., Skelton, R.L. *et al.* (2007). "Construction of sequence-tagged high density genetic map of Papaya for comparative structural and evolutionary genomics in brassicales". *Genetics* 177: 2481-2491
- Cherif, E., Zehdi, S., Castillo, K., Chabrilange, N., Abdoukader, S., Pintaud, J.C. *et al.* (2013). "Male specific DNA markers provide genetic evidence of an XY chromosomal system, a recombination arrest and allow the tracing of paternal lineage in date palm". *New Phytol* 197: 409-415
- Cherif, E., Zehdi, S., Castillo, K., Chabrilange, N., Abdoukader, S., Pintaud, J. C. *et al.* (2013). "Male specific DNA markers provide genetic evidence of an XY chromosomal system, a recombination arrest and allow the tracing of paternal lineage in date palm". *New Phytol.* 197: 409–415.
- Costantini, L., Battilana, J., Lamaj, F., Fanizza, G. and Grando, M.S. (2008). "Berry and phenology-related traits in grapevine (*Vitis Vinifera* L.): From quantitative trait loci to underlying genes". *BMC Plant Biol.* 8: 38.
- Costantini, L., Battilana, J., Lamaj, F., Fanizza, G. and Grando, M.S. (2008). "Berry and phenology-related traits in grapevine (*Vitis vinifera* L.): From quantitative trait loci to underlying genes". *BMC Plant Biol* 8: 38
- Costich, D. E. and Meagher, T. R. (1992). "Genetic variation in *Ecballium elaterium*: Breeding system and geographic distribution". *J. Evol. Biol.* 5: 589–601.
- Costich, D.E. and Meagher, T.R. (1992). "Genetic variation in *Ecballium elaterium*: Breeding system and geographic distribution". *J Evol Biol* 5: 589-601
- Cunado, N., Navajas, P.R., de la Herran, R., Ruiz, R.C., Ruiz, R.M., Santos, J.L. and Garrido-Ramos, M.A. (2007). "The evolution of sex chromosomes in the genus *Rumex* (Polygonaceae): Identification of a new species with heteromorphic sex chromosomes".

Chromosome Res 15:825-832

- Cunado, N., Navajas-Perez, R., de la Herran, R., Ruiz, Rejon, C., Ruiz Rejon, M., Santos, J. L. and Garrido-Ramos, M. A. (2007). "The evolution of sex chromosomes in the genus *Rumex* (Polygo-naceae): Identification of a new species with heteromorphic sex chromosomes". *Chromosome Res.* **15**: 825–832.
- Delichere, C.J., Veuskens, M., Hernould, M., Barbacar, N., Mouras, A., Negrutiu, I. and Moneger, F. (1999). "SIY1, the first active gene cloned from a plant Y chromosome, encodes a WD-repeat protein". *EMBO journal* **18**: 4169-4179
- Dellaporta, S.L. and Calderon, A-Urrea. (1993). "Sex determination in flowering plants". *Plant Cell* **5**: 1241-1251
- Delph, L. F., Arntz, A. M., Scotti-Saintagne, C. and Scotti, I. (2010). "The genomic architecture of sexual dimorphism in the dioecious plant *Silene latifolia*". *Evolution* **64**: 2873–2886.
- Deng, C. L., Qin, R. Y., Wang, N. N., Cao, Y., Gao, J., Gao, W. J. and Lu, L. D. (2012). "Karyotype of asparagus by physical mapping of 45S and 5S rDNA by FISH". *J. Genet.* **91**: 209–212.
- Deng, C.L., Qin, R.Y., Wag, N.N., Cao, Y., Gao, W.J. and Lu, L.D. (2012). "Karyotype of asparagus by physical mapping of 45S and 5S rDNA by FISH". *J Genet* **91**: 209-212
- Deputy, J. C., Ming, R., Ma, H., Liu Z., Fitch, M. M., Wang, M. *et al.* (2002). "Molecular markers for sex determination in papaya (*Carica papaya* L.)". *Theor. Appl. Genet.* **106**: 107–111.
- Deputy, J.C., Ming, R., Ma, H., Liu, Z., Fitch, M.M., Wang, M. *et al.* (2002). "Molecular markers in sex determination in papaya (*Carica papaya* L.)". *Theor Appl Genet* **106**: 107-11
- Desfeux, O., Maurice, S., Henry, J. P., Lejeune, B. and Gouyon, P.H. (1996). "Evolution of reproductive systems in the genus *Silene*". *Proc. R. Soc. London, Ser. B.* **263**: 409–414.
- Di Stilio, V.S., Kesseli, R.V. and Mulcahu, D.L. (1998). "A pseudoautosomal random amplified polymorphic DNA marker for sex chromosome of *Silene dioica*". *Genetics* **149**: 2057-2062
- Diggle, P. K., Di, Stilio, V. S., Gschwend, A. R., Golenberg, E. M., Moore, R. C., Russell, J. R. and Sinclair, J. P. (2011). "Multiple developmental processes underlie sex differentiation in angiosperm". *Trends Genet.* **27**: 368–376.
- Diggle, P.K., Di Stilio, V.S., Gschwend, A.R., Golenberg, E.M., Moore, R.C., Russel, J.R. and Sinclair, J.P. (2011). "Multiple development processes underlie sex differentiation in angiosperm". *Trends Genet* **27**: 368-376
- Di-Stilio, V. S., Kesseli, R. V. and Mulcahy, D. L. (1998). "A pseudoau-tosomal random amplified polymorphic DNA marker for the sex chromosomes of *Silene dioica*". *Genetics* **149**: 2057–2062.
- Divashuk, M.G., Alexandrov, O. S., Kroupin, P. Y. and Karlov, G.
- Divashuk, M.G., Alexandrov, O.S., Kroupin, P.Y. and Karlov, G.I. (2011). "Molecular cytogenetic mapping of *Humulus lupulus* sex chromosome". *Cytogenet. Genome Res* **134**: 213-219
- Dnilova, T.V. and Karlov, G.I. (2006). "Application of inter simple sequence repeat (ISSR) polymorphism for detection of sex-specific molecular markers in hop (*Humulus lupulus* L.)". *Euphytica* **151**: 15-21
- Donnison, I. S., Siroky, J., Vyskot, B., Saedler, H. and Grant, S. R. (1996). "Isolation of Y chromosome-specific sequences from *Silene latifolia* and mapping of male sex-determining genes using representational difference analysis". *Genetics* **144**: 1893–1901.
- Donnison, I.S., Siroky, J., Vyskot, B., Saedler, H. and Grant, S.R. (1996). "Isolation of Y chromosome-specific sequences from *Silene latifolia* and mapping of male sex-determining genes using representational difference analysis". *Genetics* **144**: 1893-1901
- Dorken, M. E. and Barrett, S. C. (2004). "Sex determination and the evolution of dioecy from monoecy in *Sagittaria latifolia* (Alismataceae)". *Proc. Biol. Sci.* **271**: 213–219.
- Ehsanpour, A. A., Tavassoli, M. and Arab, L. (2008). "Sex determination of *Pistacia vera* L. using ISSR markers". *Malays. Agric. Biol.* **37**: 25–28.
- Elze, H. and Pannell, J. (2011). "Sexual dimorphism in androdioecious *Mercurialis annua*, a wind-pollinated herb". *Int. J. Plant Sci.* **172**: 49–59.
- Eppley, S. M., Maureen, L. S. and Grosberg, R. K. (1998). "Intrapopulation sex ratio variation in the salt grass *Distichlis spicata*". *Am. Nat.* **152**: 659–670.
- Eppley, S.M., Mauren, L.S. and Grosberg, R.K. (1998). "Intrapopulation sex ratio variation in the salt grass *Distichlis spicata* Am Nat **152**: 659-670
- Ereeman, D.C., Wachocki, B.A., Stender, M.J., Goldschlag, D.E. and Michaels, H.J. (1994). "Seed size and sex ration in spinach, application of the Trivers-Willard hypothesis to plants". *Ecoscience* **1**: 54-63
- Farbos, I., Veuskens, J., Vyskot, B., Oliveira, M., Hinnisdaels, S., Aghmir, A. *et al.* (1999). "Sexual dimorphism in white campion: deletion on the Y chromosome results in a floral asexual phenotype". *Genetics* **151**: 1187–1196.

- Favarger, C. (1946). "Recherches caryologiques sur la sous-famille des silenoïdées". *Bull. Soc. Bot. Suisse* 56: 365-451
- Felsenstein, J. (1974). "The evolutionary advantage of recombination". *Genetics* 78: 737-756.
- Filatov, D. A. (2005a). "Evolutionary history of *Silene latifolia* sex chromosomes revealed by genetic mapping of four genes". *Genetics* 170: 975-979.
- Filatov, D. A. (2005b). "Substitution rates in a new *Silene latifolia* sex-linked gene, *SlssX/Y*". *Mol. Biol. Evol.* 22: 402-408.
- Filatov, D. A. and Charlesworth, D. (2002). "Substitution rates in the X- and Y-linked genes of the plants, *Silene latifolia* and *S. dioica*". *Mol. Biol. Evol.* 19: 898-907.
- Filatov, D. A., Laporte, V., Vitte, C. and Charlesworth, D. (2001). "DNA diversity in sex-linked and autosomal genes of the plant species *Silene latifolia* and *Silene dioica*". *Mol. Biol. Evol.* 18: 1442-1454.
- Filatov, D. A., Moneger, F., Negruțiu, I. and Charlesworth, D. (2000). "Evolution of a plant Y-chromosome: Variability in a Y-linked gene of *Silene latifolia*". *Nature* 404: 388-390.
- Finnegan, E.J., Peacock, W.J. and Dennis, E.S. (2000). "DNA methylation, a key regulator of plant development and other processes". *Current Opinion in Genetics and Development* 10:217-223
- Foster, R. (1933). "Chromosome number in *Acer* and *Staphylea*". *J. Arnold. Arbor* 14: 386-393
- Fraser, L. G., Tsang, G. K., Datson, P. M., De, Silva, H. N., Harvey, C. F., Gill, G. P. *et al.* (2009). "A gene-rich linkage map in the dioecious species *Actinidia chinensis* (kiwifruit) reveals putative X/Y sex determining chromosomes". *BMC Genomics* 10: 102.
- Fraser, L.G., Tsang, G.K., Datson, P.M., De Silva, H.M., Harvey, C.F., Gill, G.P. *et al.* (2009). "A gene-rich linkage map in dioecious species *Actinidia chinensis* (kiwifruit) reveals putative X/Y sex determining chromosome". *BMC Genomics* 10: 102
- Freeman, D. C., Wachocki, B. A., Stender, M. J., Goldschlag, D. E. and Michaels, H. J. (1994). "Seed size and sex ratio in spinach, application of the Trivers-Willard hypothesis to plants". *Ecoscience* 1: 54-63.
- Gadella, T.W.J., Kliphuis, E. (1966). "Chromosome numbers of flowering plants in the Netherlands". II. *Kon. Nederl. Akad. Wet. Proc. Ser. C* 69: 541-556
- Galan, F. (1946). "Sur la genétique de la monoécie et la dioécie zygotique chez *Ecballium eletarium* Rich". *Crit. Rev. Hebd. Seances Acad. Sci. Paris* 222: 1130-1131.
- Galan, F. (1946). "Sur la genétique de la monoécie et la dioécie zygotique chez *Ecballium eletarium* Rich". *Crit. Rev. Hebd. Seances Acad. Sci. Paris* 222: 1130-1131.
- Gangopadhyay, G., Roy, S. K., Ghose, K., Poddar, R., Bandyopadhyay, T., Basu, D. and Mukherjee, K. K. (2007). "Sex detection of *Carica papaya* and *Cycas circinalis* in pre-flowering stage by ISSR and RAPD". *Curr. Sci.* 92: 524-526.
- Gangopadhyay, G., Roy, S. K., Ghose, K., Poddar, R., Bandyopadhyay, T., Basu D. and Mukherjee, K. K. (2007). "Sex detection of *Carica papaya* and *Cycas circinalis* in pre-flowering stage by ISSR and RAPD". *Curr. Sci.* 92: 524-526.
- Gao, W. J., Li R. L., Li, S. F., Deng, C. L. and Li, S. P. (2007). "Identification of two markers linked to the sex locus in dioecious *Asparagus officinalis* plants". *Russ. J. Plant Physiol.* 54: 816-821.
- Gao, W. J., Li, R. L., Li, S. F., Deng, C. L. and Li, S. P. (2007). "Identification of two markers linked to the sex locus in dioecious *Asparagus officinalis* plants". *Russ. J. Plant Physiol.* 54: 816-821.
- George, J., Karun, A., Manimekalai, R., Rajesh, M.K. and Remya, P. (2007). "Identification of RAPD markers linked to sex determination in palmyrah (*Borassus flabellifer* L.)". *Curr. Sci* 92: 524-526
- George, J., Karun, A., Manimekalai, R., Rajesh, M. K. and Remya, P. (2007). "Identification of RAPD markers linked to sex determination in palmyrah (*Borassus flabellifer* L.)". *Curr. Sci.* 93: 1075-1077.
- Gill, G. P., Harvey, C. F., Gardner, R. C. and Fraser, L. G. (1998). "Development of sex-linked PCR markers for gender identification in *Actinidia*". *Theor. Appl. Genet.* 97: 439-445.
- Gill, G.P., Harvey, C.F., Gardner, R.C. and Fraser, L.G. (1998). "Development of sex-linked PCR markers for gender identification in *Actinidia*". *Theor. Appl. Genet* 97: 439-445
- Goldberg, M. T., Spigler, R. B. and Ashman, T.-L. (2010). "Comparative genetic mapping points to different sex chromosomes in sibling species of wild strawberry (*Fragaria*)". *Genetics* 156: 1425-1433.
- Goldberg, M.T., Spigler, R.B. and Ashman, T.-L. (2010). "Comparative genetic mapping points to different sex chromosomes in sibling species of wild strawberry (*Fragaria*)". *Genetics* 156: 1425-1433
- Gorelick, R. (2005). "Theory for why dioecious plants have equal length chromosomes". *Am. J. Bot.* 92: 979-984.
- Grabowska-Joachimiak, A., Mosiolock, M., Lech, A. and Goralski, G. (2011). "C-banding/DAP1 and *in situ* hybridisation represents the karyotype structure and sex chromosome differentiation in *Humulus japonicus* Siebold and Zucc". *Cytogenet. Genome. Res* 132: 203-211

- Grabowska- Joachimiak, A., Seliwinska, E., Pigula, M., Skomra, U. and Joachimiak, A.J. (2006). "Genome size in *Humulus lupulus* L. And *H. Japonicus* Siebold and Zucc (Cannabaceae)". *Acta. Soc. Bot. Pol.* 75: 207-214
- Grabowska-Joachimiak, A. and Jochimiak, A. (2002). "C-banded kary otypes of two *Silene* species with heteromorphic sex chromo- somes". *Genome* 45: 243–252.
- Grabowska-Joachimiak, A., Mosiolek, M., Lech, A. and Goralski, G. (2011). "C-banding/DAP1 and *in situ* hybridization reflect karyotype structure and sex chromosome differentiation in *Humulus japoni-cus* Siebold and Zucc. *Cytogenet*". *Genome Res.* 132: 203–211.
- Grabowska-Joachimiak, A., Seliwinska, E., Pigula, M., Skomra, U. and Joachimiak, A. J.( 2006). "Genome size in *Humulus lupulus* L. and *H. japonicus* Siebold and Zucc (Cannabaceae)". *Acta. Soc. Bot. Pol.* 75: 207–214.
- Grabowska-Joachimiak, A., Seliwinska, E., Pigula, M., Skomra, U. and Joachimiak, A. J. (2006). "Genome size in *Humulus lupulus* L. and *H. japonicus* Siebold and Zucc (Cannabaceae)". *Acta. Soc. Bot. Pol.* 75: 207–214.
- Gschwend, A., Yu, Q., Tong, E. J., Zeng, F., Han, J., VanBuren, R. *et al.* (2012). "Rapid divergence and expansion of the X chromosome in papaya". *Proc. Natl. Acad. Sci. USA* 109: 13716–13721.
- Gschwend, A., Yu, Q., Tong, E.J., Zenf, F., Han, J., VanBuren, R. *et al.* (2003). " Rapid divergence and expansion of X chromosome in Papaya". *Proc. Natl. Acad. Sci. USA* 109: 13716-13721
- Gunter, L. E., Roberts, G. T., Lee, K., Larimer, F. W. and Tuskan, G. A. (2003). "The development of two flanking SCAR markers linked to a sex determination locus in *Salix viminalis*". *J. Hered.* 94: 185–189.
- Gunter, L.E., Roberts, G.T., Lee, K., Larimer, F.W. and Tuskan, G.A. (2003). " The development of teo flanking SCAR markers linked to a sex determination locus in *Salix viminalis*". *J. Hered.* 94: 185-189
- Haga, T. ( 1935). "Sex and chromosomes in *Spinacia oleracea* L.". *Idengaku Zashhi* 10: 218-222
- Hamilton, W. D. (1967). "Extraordinary sex ratios". *Science* 156: 477–488.
- Harris, M. S. and Pannell, J. R. (2010.) "Canopy seed storage is asso- ciated with sexual dimorphism in the woody dioecious genes *Leucadendron*". *J. Ecol.* 98: 509–515
- Harvey, C. F., Gill, G. P., Fraser, L. G. and McNeilage, M. A. (1997). "Sex determination in *Actinidia*. 1. Sex-linked markers and progeny sex ratio in diploid *A. chinensis*". *Sex Plant Reprod.* 10: 149–154.
- Heslop-Harrison, J.W. (1926). "Heterochromosomes and polyploidy". *Nature* 117: 50
- Hizume, M., Shiraishi, H. and Tanaka, A. (1988). "A cytological study of *Podocarpus macrophyllus* with special reference to sex chromosomes". *Jap. J. Genet.* 63: 413–423.
- Hobza, R., Kejnovsky, E., Vyskot, B. and Widmer, A. (2007). "The role of chromosomal rearrangements in the evolution of *Silene latifolia* sex chromosomes". *Mol. Genet. Genomics* 278: 633–638.
- Hobza, R., Lengerova, M., Svoboda, J., Kubekova, H., Kejnovsky, E. and Vyskot, B. (2006). "An accumulation of tandem DNA repeats on the Y chromosome in *Silene latifolia* during early stages of sex chromosome evolution". *Chromosoma* 115: 376–382.
- Hofmeyr, J. D. J. (1938). "Genetic studies of *Carica papaya* L". *S. Afr. J. Sci.* 35: 300–304.
- Holstein, N. (2012). "Evolution, biogeography, and monographic treatment of *Coccinia* (Cucurbitaceae)". Ph.D. thesis, Ludwig-Maxmilians University, Munich, Germany.
- Holstein, N. and Renner, S. S. (2011). "Niche conservation? Biome switching within and between species of the African genus *Coccinia* (Cucurbitaceae)". *BMC Evol. Biol.* 11: 28.
- Holstein, N. and Renner, S.S. (2011). "Niche conversion? Biome switching within and between species of the African genus *Coccinia* (Cucurbitaceae)". *BMC Evol. Biol* 11: 28
- Hormuza, J. I., Dollo, L. and Polito, V. S. (1994). "Identification of RAPD marker linked to sex determination in *Pistacia vera* using bulked segregant analysis". *Theor. Appl. Genet.* 89: 9–13.
- Hormuza, J.I., Dollo, L. and Polito, V.S. (1994). " Identification of RAPD marker linked to sex determination in *Pistacia ver* using bulked segregant analysis". *Theor. Appl. Genet.* 89: 9-13
- Horovitz, S. and Jimenez, H. (1967). "Cruzamientos interspecificos e intergenericos en cariaceas y sus implicaciones fitotecnicas". *Agronomia Tropical* 17: 323-343
- Hou, W., Fan, J., Zhou, F. and Zhao, S. (2009). "RAPD markers related to sex locus in *Populus tomentose*". *Front. For. Chin* 4: 223–226.
- Hou, W., Fan, J. and Zhao, S. (2009). "RAPD markers related to sex locus in *Populus tomentose*". *Front. For. Chin* 4: 223-226
- Hough, J., Immler, S., Barrett, C. H. and Otto, S. P. (2013). "Evolution-arily stable sex ratios and mutation load". *Evolution* 67: 1915–1925.

- Howell, E. C., Armstrong, S. and Filatov, D. (2009). “b Evolution of neo-sex chromosomes in *Silene diclinis*”. *Genetics* **182**: 1109–1115.
- Howell, E. C., Armstrong, S. J. and Filatov, D. A. (2009). “a Evolution of neo-sex chromosomes in *Silene diclinis*”. *Genetics* **182**: 1109–1115.
- Howell, E.C., Armstrong, S.J. and Filatov, D.A. (2009)a. “Evolution of neo-sex chromosomes in *Silene diclinis*”. *Genetics* **182**: 1109–1115
- Howell, E.C., Armstrong, S.J. and Filatov, D.A. (2009)b. “Evolution of neo-sex chromosomes in *Silene diclinis*”. *Genetics* **182**: 1109–1115
- Hussaini, F.S., Hassani, H.S., Arvin, M.J., Baghizadeh, A. and Mohammadi-Nejad, G. (2011). “Sex determination of jojoba (*Simmondsia chinensis* cv Arizona) by random amplified polymorphic DNA (RAPD) molecular markers”. *Afr. J. Biotech.* **10**: 470–474
- Hussaini, F. S., Hassani, H. S., Arvin, M. J., Baghizadeh, A. and Mohammadi-Nejad, G. (2011). “Sex determination of jojoba (*Simmondsia chinensis* cv Arizona) by random amplified poly-morphic DNA (RAPD) molecular markers”. *Afr. J. Biotech.* **10**: 470–474.
- I. (2011). “Molecular cytogenetic mapping of *Humulus lupulus* sex chromosomes”. *Cytogenet. Genome Res.* **134**: 213–219.
- Ironside, J. E. and Filatov, D. A. (2005). “Extreme population structure and high interspecific divergence of the *Silene* Y-chromosome”. *Genetics* **171**: 705–713.
- Jackson, S.W. (1967). “A biosystematic study of *Rumex hastatulus*”. Ph. D. Thesis, North Carolina State Univ, Raleigh USA: 154
- Jacobsen, P. (1957). “The sex chromosomes in *Humulus L.*”. *Hereditas* **43**: 357–370
- Jakse, J., Stajner, N., Kozjak, P., Cerenak, A. and Javornik, B. (2008). “Trinucleotide micro-satellite repeat is tightly linked to male sex in hop (*Humulus lupulus L.*)”. *Mol. Breed.* **21**: 139–148.
- Jamilena, M., Marriotti, B. and Manzano, S. (2008). “Plant sex chromosomes: molecular structure and function”. *Cytogenet. Genome Res.* **120**: 255–264.
- Jensen, H.W. (1936). “Meiosis in *Rumex* II. The origin and behavior of the so-called sex chromosomes in *Rumex*”. *Cytologia* **7**: 23–34
- Jiang, C. and Sink, K. C. (1997). “RAPD and SCAR markers linked to the sex expression locus M in asparagus”. *Euphytica* **94**: 329–333.
- Jiang, C. and Sink, K.C. (1997). “RAPD and SCAR markers linked to the sex expression locus M in asparagus”. *Euphytica* **94**: 329–333
- Johnson, L.A.S., Briggs, B.C. (1962). “Taxonomical and cytological notes on *Acetosa* and *Acetosella* in Australia”. *Contr. N.S.W. Hatl. Herb* **3**: 165–169
- Johnsson, H. (1940). “Cytological studies of diploid and triploid *Populus tremula* and of crosses between them”. *Hereditas* **26**: 321–352
- Kafer, J., Talianova, M., Bigot, T., Michu, E., Gueguen, L., Widmer, A. *et al.* (2013). “Patterns of molecular evolution in dioecious and non-dioecious *Silene*”. *J. Evol. Biol.* **26**: 335–346
- Kafer, J., Talianova, M., Bigot, T., Michu, E., Gueguen, L., Widmer, A. *et al.* (2013). “Patterns of molecular evolution in dioecious and non-dioecious *Silene*”. *J. Evol. Biol.* **26**: 335–346.
- Kaiser, V. B., Bergero, R. and Charlesworth, D. (2009). “Slcvt, a newly identified sex-linked gene, has recently moved onto the X chromosome in *Silene latifolia* (Caryophyllaceae)”. *Mol. Biol. Evol.* **26**: 2343–2351.
- Karlov, G. L., Danilova, T. V., Horlemann, C. and Weber, G. (2003). “Molecular cytogenetic in hop (*Humulus lupulus L.*) and identification of sex chromosomes by DAPI-banding”. *Euphytica* **132**: 185–190.
- Kater, M. M., Franken, J., Carney, K. J., Colombo, L. and Angenent, G. C. (2001). “Sex determination in the monoecious cucumber is confined to specific floral whorls”. *Plant Cell* **13**: 481–493.
- Kejnovsky, E., Vrana, J., Matsunaga, S., Soucek, P., Siroky, J., Dolezel, J. and Vyskot, B. (2001). “Localization of male-specifically expressed MROS genes of *Silene latifolia* by PCR on flow-sorted sex chromosomes and autosomes”. *Genetics* **158**: 1269–1277.
- Khadka, D. K., Nejidat, A., Tal, M. and Golan-Goldhirsh, A. (2002). “DNA markers for sex: molecular evidence for gender dimorphism in dioecious *Mercurialis annua L.*”. *Mol. Breed.* **9**: 251–257.
- Khadka, D. K., Nejidat, A., Tal, M. and Golan-Goldhirsh, A. (2005). “Molecular characterization of a gender-linked DNA marker and a related gene in *Mercurialis annua L.*”. *Planta* **222**: 1063–1070.
- Khattak, J. Z. K., Torp, A. M. and Andersen, S. B. (2006). “A genetic linkage map of *Spinacea oleracea* and localization of a sex determination locus”. *Euphytica* **148**: 311–318.

- Kihara, H. (1929). "The sex chromosomes of *Humulus japonicus*". Idengaku Zasshu 4: 55-63
- Kihara, H. (1930). "Karyologische Studien an *Fragaria* mit besonderer Berücksichtigung der Geschlechtschromosomen". Cytologia 1: 345-357
- Kihara, H. (1930). "Karyologische Studien an *Fragaria* mit besonderer Berücksichtigung der Geschlechtschromosomen". Cytologia 1: 345-357
- Kihara, H. and Ono, T. (1923). "Cytological studies of *Rumex* L.". Bot. Mag. 37: 84-90.
- Kihara, H., Ono, T. (1925). "The sex chromosomes of *Rumex acetosa*". Z. Vererb 39: 1-7
- Kihara, H., Yamamoto, Y. (1935). "Chromosomenverhältnisse bei *Aucuba chinensis*". Benth. Arg. And Hort. 10: 2485-2496
- Kim, S.-Y., Kim, C.-S., Lee, J. and Bang, J.-W. (2008). "Karyotype analysis and physical mapping using two rRNA genes in dioecious plant, *Humulus japonicus* Siebold and Zucc". Genes Genomics 30: 157-161.
- Kumar, L. S. S. and Visevshwaraiyah, S. (1952). "Sex mechanism in *Coccinia indica* Wight and Arn". Nature 170: 330-331.
- Kumar, S. (2007). "Conventional and new concepts of species and genetic mechanisms for the origin of species". Proc. Ind. Natl. Sci. Acad. 73: 111-120.
- Kumar, S., Singh, B. D., Sinha, D. P. and Rai, M. (2008). "Sex expression-associated RAPD markers in pointed gourd (*Trichosanthes dioica*)". In *Proceedings of the IXth EUCARPIA meeting on genetics and breeding of Cucurbitaceae* (ed. M. Pirat), pp. 543-550. Avignon, France.
- Kumar, S., Singh, B.D., Sinha, D.P. and Rai, M. (2008). "Sex expression associated RAPD markers in pointed gourd (*Trichosanthes dioica*)". In *Proceedings of IXth EUCARPIA meeting on Genetics and breeding of Cucurbitaceae* (ed. M. Pirat), Avignon, France, pp 543-550
- Kumar, Sushil, Kumari, Renu and Sharma, Vishakha. "Genetics of dioecy and causal sex chromosomes in plant", Journal of Genetics Vol 93 No 1 April 2014.
- Kurita, M. and Kuroki, Y. (1970). "Y-chromosome and heterochromatin in *Rumex acetosa*". Jpn. J. Genet. 45: 255-260.
- Lan, T., Zhang, S., Liu, B., Li, X., Chen, R. and Song, W. (2006). "Differentiating sex chromosomes of the dioecious *Spinacia oleracea* L. (spinach) by FISH of 45S rDNA". *Cytogenet. Genome Res.* 114: 175-177.
- Lan, T., Zhang, S., Liu, B., Li, X., Chen, R. and Song, W. (2006). "Differentiating sex chromosomes of dioecious *Spinacia oleracea* L. (spinach) by FISH of 45S rDNA". *Cytogenet. Genome Res.* 114: 175-177
- Lebel-Hardenack, S., Hauser, E., Law, T. F., Schmid, J. and Grant, S. R. (2002). "Mapping of sex determination loci on the white campion (*Silene latifolia*) Y chromosome using amplified fragment length polymorphism". *Genetics* 160: 717-725.
- Lengerova, M., Kejnovsky, E., Hobza, R., Macas, J., Grant, S. R. and Vyskot, B. (2004). "Multicolor FISH mapping of the dioecious model plant, *Silene latifolia*". *Theor. Appl. Genet.* 108: 1193-1199.
- Lengerova, M., Kejnovsky, E., Hobza, R., Macas, J., Grant, S. R. and Vyskot, B. (2004). "Multicolor FISH mapping of the dioecious model plant, *Silene latifolia*". *Theor. Appl. Genet.* 108: 1193-1199.
- Lengerova, M., Moore, R. C., Grant, S. R. and Vyskot, B. (2003). "The sex chromosomes of *Silene latifolia* revisited and revised". *Genetics* 165: 935-938.
- Lengerova, M., Moore, R. C., Grant, S. R. and Vyskot, B. (2003). "The sex chromosomes of *Silene latifolia* revisited and revised". *Genetics* 165: 935-938.
- Lengerova, M., Moore, R.C., Grant, S.R. and Vyskot, B. (2003). "The sex chromosome of *Silene latifolia* revisited and revised". *Genetics* 165: 935-938
- Lengerova, M., Kejnovsky, E., Hobza, R., Macas, J., Grant, S.R. and Vyskot, B. (2004). "multicolor FISH mapping of the dioecious model plant, *Silene latifolia*". *Theor. Appl. Genet.* 108: 1193-1199
- Lewis, D. (1942). "The evolution of sex in flowering plants". *Biolog. Rev.* 17: 46-67.
- Liu, Z., Moore, P. H., Ma, H., Ackerman, C. M., Ragiba, M., Yu, Q. and Pearl, H. M. (2004). "A primitive Y chromosome in papaya marks incipient sex chromosome evolution". *Nature* 427: 348-352.
- Loptien, H. (1979). "Identification of the sex chromosome pair in asparagus (*Asparagus officinalis* L.)". *Z. Pflanzenzucht.* 82: 162-173.
- Love, A. (1957). "Sex determination in *Rumex*". *Proc. Genet. Soc. Can* 2: 31-36
- Love, A. (1967). "IOPB chromosome number reports". XIII. *Taxon* 16: 445-461
- Love, A., Evenson, V. (1967). "The taxonomic status of *Rumex paucifolius*". *Taxon* 16: 423-425
- Love, A., Kapoor, B.M. (1967). "A chromosome Atlas of the collective genus *Rumex*". *Cytologia* 32

- Love, A., Love, D. (1945). "Experiments on the effects of animal sex hormones on dioecious plants". *Ark. Bot.* 32A (13): 1-60
- Love, A., Sarkar, N. (1956). "Cytotaxonomy and sex determination of *Rumex paucifolius*". *Canad. J. Bot.* 34: 261-268
- Love, A. and Love, D. (1942). "Cytotaxonomic studies on boreal plants". I. *Kgl. Fysiograf. Sällskap. Lund Forh* 12: 1-9
- Ma, H., Moore, P. H., Liu, Z., Kim, M. S., Yu, Q., Fitch, M. M. M. et al. (2004). "High-density linkage mapping revealed suppression of recombination at the sex determination locus in papaya". *Genetics* 166: 419-436.
- Ma, H., Moore, P.H., Liu, Z., Kim, M.S., Yu, Q., Fitch, M.M., Sekioka, T., Paterson, A.H. and Ming, R. (2004). "High density linkage mapping revealed suppression of recombination at the sex determination locus in papaya". *Genetics* 166: 419-436
- Macas, J., Kejnovsky, E., Neumann, P., Novak, P., Koblizkova, A. and Vyskot, B. (2008). "Next generation sequencing-based analysis of repetitive DNA in the model dioecious plant *Silene latifolia*". *PLoS One* 6, e27335.
- Magdum, S., Banerjee, U., Murugan, P., Gangapur, D. and Ravikesvan, R. (2013). "Gene duplication as a major force in evolution". *J. Genet.* 92: 155-161.
- Mandolino, G., Carboni, A., Forapani, S., Faeti, V. and Ranalli, P. (1999). "Identification of DNA markers linked to the male sex in dioecious hemp (*Cannabis sativa* L.)". *Theor. Appl. Genet.* 98: 86-92.
- Mandolino, G., Carboni, A., Forapani, S., Faeti, V. and Ranalli, P. (1999). "Identification of DNA markers linked to the male sex in dioecious hemp (*Cannabis sativa* L.)". *Theor. Appl. Genet.* 98: 86-92.
- Mandolino, G., Carboni, A., Forapani, S., Faeti, V. and Ranalli, P. (1999). "Identification of DNA markers linked to the male sex in dioecious hemp (*Cannabis sativa* L.)". *Theor. Appl. Genet.* 98: 86-92
- Manoj, P., Banerjee, N. S. and Ravichandran, P. (2005). "Development of sex-associated SCAR markers in *Piper longum* L". *PGR Newslett.* 141: 44-50.
- Manoj, P., Banerjee, S.N. and Ravichandran, P. (2005). "Development of sex-associated SCAR markers in *Pipum longum* L.". *PGR Newslett* 141: 44-50
- Marais, G. A. B., Forrest, A., Kamau, E., Kafer, J., Daubin, V. and Charlesworth, D. (2011). "Multiple nuclear gene phylogenetic analysis of the evolution of dioecy and sex chromosomes in the genus *Silene*". *PLoS One* 6, e21915.
- Marais, G. A. B., Nicolas, M., Bergero, R., Chambrier, P., Kejnovsky, E., Moneger, F. et al. (2008). "Evidence for degeneration of the Y-chromosome in the dioecious plant *Silene latifolia*". *Curr. Biol.* 18: 545-549.
- Marguerit, E., Boury, C., Manicki, A., Donnart, M., Butterlin, G., Nemorin, A., Wiedemann-Merdinoglu, S. et al. (2009). "Genetic dissection of sex determinism, inflorescence morphology and downy mildew resistance in grapevine". *Theor. Appl. Genet.* 118: 1261-1278.
- Marin, I., Siegal, M. L. and Baker, B. S. (2000). "The evolution of dosage-compensation mechanisms". *BioEssays* 22: 1106-1114.
- Mariotti, B., Manzano, S., Kejnovsky, E., Vyskot, B. and Jamilena, M. (2009). "Accumulation of Y-specific satellite DNAs during the evolution of *Rumex acetosa* sex chromosome". *Mol. Genet. Genomics* 281: 249-259.
- Mariotti, B., Manzano, S., Kejnovsky, E., Vyskot, B. and Jamilena, M. (2009). "Accumulation of Y-specific satellite DNAs during the evolution of *Rumex acetosa* sex chromosome". *Mol. Genet. Genomics* 281: 249-259.
- Mariotti, B., Manzano, S., Kejnovsky, E., Vyskot, B. and Jamilena, M. (2009). "Accumulation of Y-specific satellite DNAs during evolution of *Rumex acetosa* sex chromosome". *Mol. Genet. Genomics* 281: 249-259
- Mariziani, G., Caporali, E. and Spada, A. (1999). "Search for genes involved in asparagus sex-determination". In "Sex determination in plants" (ed. C. C. Ainsworth) pp. 149-162. Bios Scientific Publishers, Oxford, UK.
- Martin, F. W. (1966). "Sex ratio and sex determination in *Dioscorea*". *J. Hered* 57: 95-99.
- Martin, F.W. (1996). "Sex ration and sex determination in *Dioscorca*". *J. Hered.* 57: 95-99
- Martin, F.W., Ortiz, S. (1963). "Chromosome numbers and behavior in some species of *Dioscorea*". *Cytologia* 28: 96-101
- Mathew, P.M. (1958). "Studies on Menispermaceae". *Proc. Indian Acad. Sci. Sec B* 47(5): 274-286
- Matsunaga, S. and Kawano, S. (2001). "Sex determination by sex chromosome in dioecious plants". *Plant Biology* 3: 481-488
- McWilliams, T.L. (1930). "meiosis and pollen-grain formation in *Acnida tuberculata*". *Moq Thesis.* Univ. Wisconsin, USA
- Meurman, O. (1925). "The chromosome behavior of some dioecious plants and their relatives with special reference to sex chromosomes". *Soc. Sci. Fenn. Comm. Biol.* 2: 1-104
- Midgley, J. J. (2010). "Causes of secondary sexual differences in plants-evidence from extreme leaf dimorphism in *Leucadendron* (Priteaceae)". *South Afr. J. Bot* 76: 588-592.
- Milewicz, M. and Sawicki, J. (2013). "Sex linked markers in dioecious plants". *POJ.* 6: 144-149.
- Miller, J. S. and Venable, D. L. (2000). "Polyploidy and the evolution of gender dimorphism in plants". *Science.* 289: 2335-2338.
- Ming, R., Bendahmane, A. and Renner, S. S. (2011). "Sex chromosomes in land plants". *Ann. Rev. Plant Biol.* 62: 485-574.

- Ming, R., Hou, S., Feng, Y., Yu, Q., Dionne-Laporte, A., Saw, J. H. et al. (2008). "The draft genome of the transgenic tropical fruit tree papaya (*Carica papaya* Linnaeus)". *Nature* 452: 991–996.
- Mitchell, C. H. and Diggle, P. K. (2005). "Evolution of unisexual flowers: morphological and functional convergence results from diverse developmental transitions". *Am. J. Bot.* 92: 1068–1076.
- Mittwoch, U. (1996). "Differential implantation rates and variations in the sex ratio". *Human Reproduction* 11: 8–9
- Moore, R. C., Kozyreva, O., Lebel-Hardenack, S., Siroky, J., Hobza, R., Vyskot, B. and Gran, S. R. (2003). "Genetic and functional analysis of DD44, a sex-linked gene from the dioecious plant *Silene latifolia* provides clues to early events in sex chromosome evolution". *Genetics*. 163: 321–334.
- Mrackova, M., Nicolas, M., Hobza, R., Negrutiu, I., Moneger, F., Widmer, A. et al. (2008). "Independent origin of sex chromosomes in two species of genus *Silene*". *Genetics*. 179:1129–1133.
- Muller, H. J. (1964). "The relation of recombination to mutational advance". *Mut. Res.* 106: 2–9.
- Muntzing, A. (1936). "The chromosomes of a giant *Populus tremula*". *Hereditas* 32: 383–393
- Murray, M. J. (1940). "The genetics of sex determination in the family Amaranthaceae". *Genetics*. 35: 409–431.
- Mwase, W. F., Erik-Lid, S., BjOrnstad, A., Stedje, B., Kwapata, M. B. and Bokosi, J. M. (2007). "Application of amplified fragment length polymorphism (AFLPs) for detection of sex-specific markers in dioecious *Uapaca kirkiana*". *Muell Arg. Afr. J. Biotechnol.* 6: 137–142.
- Mwase, W.F., Erik-Lid, S., BjOrnstad, A., Stedje, B., Kwapata, M.B. and Bokosi, J.M. (2007). "Application of amplified fragment length polymorphism (AFLPs) for detection of sex-specific markers in dioecious *Uapaca kirkiana* Muell Arg". *Afr. J. Biotechnol.* 6: 137-142
- Nakajima, G. (1937). "Cytological studies in some dioecious plants". *Cytologia (Fujii Jubil Vol)*: 282-292
- Nakajima, G. (1942). "Cytological studies in some dioecious plants, with special reference to the sex chromosomes". *Cytologia* 12: 262-270
- Navajas-Perez, R., Schwarzacher, T., Rejon, M. R. and Garrido-Ramos, M. A. (2009). "Molecular cytogenetic characterization of *Rumex papillaris*, a dioecious plant with an XX/XY(1)Y2 sex chromosome system". *Genetica*. 135: 87–93.
- Navajas-Perez, R., de la Herran, R., Lopez Gonzalez, G., Jamilena, M., Lozano, R., Ruiz Rejon, C. et al.(2005)b. "The evolution of reproductive systems and sex determining mechanisms within *Rumex* (Polygonaceae) inferred from nuclear and chloroplastidial sequence data". *Mol. Biol. Evol.* 22: 1929–1939.
- Navajas-Perez, R., la Herran, Rd, Jamilena, M., Lozano, R., RejonC, R., Rejon, M. R. and Garrido-Ramos, M. A. (2005)a. "Reduced rates of sequence evolution of Y-linked satellite DNA in *Rumex* (Polygonaceae)". *J. Mol. Evol.* 60: 391–399.
- Navajas-Perez, R., Schwarzacher, T., de la Herran, R., Ruiz Rejon, C., Ruiz Rejon, M. and Garrido-Ramos, M. A. (2006). "The origin and evolution of the variability in a Y-specific satellite-DNA of *Rumex acetosa* and its relatives". *Gene*. 368: 61–71.
- Negrutiu, I., Vyskot, B., Barbacar, N., Georgiev, S. and Moneger, F. (2001). "Dioecious plants. A key to the early events of sex chromosome evolution". *Plant Physiol.* 127: 1418–1424.
- Nicolas, M., Marais, G., Hykelova, V., Janousek, B., Laporte V., Vyskot, B. et al. (2005). "A gradual process of recombination restriction in the evolutionary history of the sex chromosomes in dioecious plants". *PLoS Biol.* 3:47–56.
- Nilsson, E. and Agren, J. (2006). "Population size, female fecundity, and sex ratio variation in gynodioecious *Plantago maritime*". *J. Evol. Biol.* 19: 825–833.
- Nishiyama, R., Ishii, K., Kifune, E., Kazama, Y., Nishihara, K., Matsunaga, S. et al. (2010). "Sex chromosome evolution revealed by physical mapping of SIAP3X/Y in the dioecious plants *Silene latifolia*". *Cytologia*. 75: 319–325.
- Obbard, D. J., Harris, S. A., Buggs, R. J. and Pannell, J. R. (2006). "Hybridization, polyploidy and the evolution of sexual systems in *Mercurialis* (Euphorbiaceae)". *Evolution*. 60:1801–1815.
- Obbard, D.J., Harris, S.A., Buggs, R.J. and Pannell, J.R. (2006). "Hybridisation, polyploidy and the evolution of sexual systems in *Mercurialis* (Euphorbiaceae)". *Evolution* 60: 1801-1815
- Ono, T. (1935). "Chromosomen und Sexualitat von *Rumex acetosa*". *Sci. Rep, Tohoku Imp. Univ.* IV 10: 41-210
- Ono, T. (1955). "Studies on hop. I. Chromosomes of common hop and its relatives". *Bull. Brew. Sci.* 2: 1–65.
- Onodera, Y., Yonaha, I., Masumo, H., Tanaka, A., Niikura, S., Yamazaki, S. and Mikami, T. (2011). "Mapping of the genes for dioecism and monoecism in *Spinacia oleracea* L.: evidence that both genes are closely linked". *Plant Cell Rep.* 30: 965–971.
- Otto, S. P. and Lenormand, T. (2002). "Resolving the paradox of sex and recombination". *Natl. Rev. Genet.* 3: 252–261.
- Otto, S. P., Pannell, J. R., Peichel, C. L., Ashman, T. L., Charlesworth, D., Chippindale, A. K. et al. (2011). "About PAR: The distinct evolutionary dynamics of the pseudoautosomal region". *Trends Genet.* 27: 358–367.

- Oyama, R. K., Silber, M. V. and Renner, S. S. (2010). "A specific insertion of a solo-LTR characterizes the Y-chromosome of *Bryonia dioica* (Cucurbitaceae)". *BMC Res. Notes*. 3: 166–173.
- Oyama, R. K., Volz, S. M. and Renner, S. S. (2009). "A sex-linked SCAR marker in *Bryonia dioica* (Cucurbitaceae); a dioecious species with XY sex-determination and homomorphic sex chromosomes". *J. Evol. Biol.* 22: 214–224.
- Pakull, B., Groppe, K., Meyer, M., Markussen, T. and Fladung, M. (2009). "Genetic linkage mapping in aspen (*Populus tremula* L. and *Populus tremuloides* Michx)". *Tree Genet. Genomics*. 5: 505–515.
- Pannell, J. R. (1997b). "Widespread functional androdioecy in *Mercurialis annua* L. (Euphorbiaceae)". *Biol. J. Linn. Soc.* 61:95–116.
- Pannell, J. R. (2008). "Gender variation and transitions between sexual systems in *Mercurialis annua*". *Int. J. Plant Sci.* 169: 129–139.
- Pannell, J. R., Obbard, D. J. and Buggs, R. J. A. (2004). "Polyploidy and the sexual system: What can we learn from *Mercurialis annua*". *Biol. J. Linn. Soc.* 82: 547–560.
- Pannell, J. (1997). "Mixed genetic and environmental sex determination in an androdioecious population of *Mercurialis annua*". *Heredity* 78: 50–56
- Pannell, J. (1997a). "Mixed genetic and environmental sex determination in an androdioecious population of *Mercurialis annua*". *Heredity*. 78: 50–56.
- Pannell, J.R. (2008). "Gender variations and transitions between sexual systems in *Mercurialis annua*". *Int. Plant. Sci.* 169: 129–139
- Paolucci, I., Gaudet, M., Jorge, V., Isacco Beritognolo, I., Terzoli, S., Kuzminsky, E. et al. (2008). "Genetic linkage maps of *Populus alba* L. and comparative mapping analysis of sex determination across *Populus* species". *Tree Genet. Genomics*. 6: 863–875.
- Paolucci, I., Gaudet, M., Jorge, V., Isacco, B.I., Terzoli, S., Kuzminsky, E. et al. (2008). "Genetic linkage maps of *Populus alba* L. and comparative mapping analysis of sex determination across *Populus* species". *Tree. Genet. Genomics* 6: 863–875
- Parasnis, A. S., Ramakrishna, W., Chowdari, K. V., Gupta, V. S. and Ranjekar, P. K. (1999). "Microsatellite (GATA)<sub>n</sub> reveals sex specific differences in papaya". *Theor. Appl. Genet.* 99: 1047–1052.
- Parasnis, A. S., Gupta, V. S., Tamhankar, S. A. and Ranjekar, P. K. (2000). "A highly reliable sex diagnostic PCR assays for mass screening of papaya seedlings". *Mol. Breed.* 6: 337–344.
- Parasnis, A.S., Gupta, V.S., Tamhankar, S.A. and Ranjekar, P.K. (2000). "A highly reliable sex diagnostic PCR assays for mass screening of papaya seedlings". *Mol. Breed.* 6: 337–344
- Parasnis, A.S., Ramakrishna, W., Chowdari, K.V., Gupta, V.S. and Rajekar, P.K. (1999). "Microsatellite (GATA)<sub>n</sub> reveals sex specific differences in papaya". *Theor. Appl. Genet.* 99: 1047–1052
- Patel, G. I. (1952). "Chromosome basis of dioecism in *Trichosanthes dioica* Roxb". *Curr. Sci.* 21: 343–344.
- Patel, G.I. (1952). "Chromosome basis of dioecism in *Trichosanthes dioica* Roxb". *Curr. Sci.* 21:343–344
- Patel, G.I. (1952). "Chromosome basis of dioecism in *Trichosanthes dioica* ROXB.". *Curr. Sci (India)* 21:343–344
- Peil, A., Flachowsky, H., Schumann, E. and Weber, W. E. (2003). "Sex-linked AFLP markers indicate a pseudoautosomal region in hemp (*Cannabis sativa* L.)". *Theor. Appl. Genet.* 107:102–109.
- Peil, A., Flachowsky, H., Schumann, E. and Weber, W.E. (2003). "Sex-linked AFLP markers indicate a pseudoautosomal region in hemp (*Cannabis sativa* L.)". *Theor. Appl. Genet.* 107: 102–109
- Persson, H. A. and Nybom, H. (1998). "Genetic sex determination and RAPD marker segregation in the dioecious species sea buckthorn (*Hippophae rhamnoides* L.)". *Hereditas.* 129: 45–51.
- Persson, H.A. and Nybom, H. (1998). "Genetic sex determination and RAPD marker segregation in dioecious species sea buckthorn (*Hippophae rhamnoides* L.)". *Hereditas* 129: 45–51
- Peto, F.H. (1938). "Cytology of poplar species and natural hybrids". *Can. J. Res.* 16: 445–455
- Polley, A., Ganal, M. W. and Seigner, E. (1997). "Identification of sex in hop (*Humulus lupulus*) using molecular markers". *Genome.* 40: 357–361.
- Polley, A., Ganal, M.W. and Seigner, E. (1997). "Identification of sex in hop (*Humulus lupulus*) using molecular markers". *Genome* 40:357–361
- Qiu, Y. L. and Palmer, J. D. (1999). "Phylogeny of early land plants: insights from genes and genomes". *Trends Plant Sci.* 4: 26–30.
- Quinn, A. E., Georges, A., Sarre, S. D., Guarino, F., Ezaz, T. and Graves, J. A. (2007). "Temperature sex reversal implies sex gene dosage in a reptile". *Science* 316, 411.
- Rahman, M. A. and Ainsworth, C. C. (2004). "AFLP analysis of genome difference between males and females in dioecious plant

- Rumex acetosa*". J. Bio. Sci. 4: 160–169.
- Rai, L. K. and Singh, K. K. (2013). " *Phoenix rupicola* in the Eastern Himalaya". Curr. Sci. 104: 572–573.
- Ramachandran, K. (1962). " Studies on cytology and sex determination on Dioscoriaceae". J. Ind. Bot. Soc. 41: 93–98
- Ranker, T. A. and Haufler, C. H. (2008). " Biology and evolution of ferns and lycophytes. Cambridge University Press, Cambridge, UK.
- Rautenberg, A., Hathaway, L., Oxelman, B. and Prentice, H. C. (2010). "Geographical phylogenetic patterns in *Silene* section *Melandrium* (Caryophyllaceae) as inferred from chloroplast and nuclear DNA sequences". Mol. Phylogenet. Evol. 57: 978–991.
- Rautenberg, A., Sloan, D. B., Alden, V. and Oxelman, B. (2012). " Phylogenetic relationships of *Silene multinervia* and *Silene* section *Conoimorpha* (Caryophyllaceae)". Syst. Bot. 37: 226–237.
- Reamon-Buttner, S. M., Schondelmaier, J. and Jung, C. (1998). " AFLP markers tightly linked to the sex locus in *Asparagus officinalis* L.". Mol. Breed. 4: 91–98.
- Rejon, C. R., Jamilena, M., Ramos, M. G., Parke, J. S. and Rejon, M. R. (1994). "Cytogenetic and molecular analysis of the multiple sex-chromosome system of *Rumex acetosa*". Heredity. 72: 209–215.
- Renganayaki, K., Jessup, R. W., Burson, B. L., Hussey, M. A. and Read, J. C. (2005). " Identification of male-specific AFLP markers in dioecious Texas bluegrass". Crop Sci. 45: 2529–2539.
- Renner, S. S. and Ricklefs, R. E. (1995). " Dioecy and its correlates in the flowering plants". Am. J. Bot. 82: 596–606.
- Renner, S.S. and Ricklefs, R.E. (1995). "Dioecy and its correlates in the flowering plants". Am. J. Bot. 82: 596-606
- Renner, S.S. and Ricklefs, R.E. (1995). "Dioecy and its correlates in the flowering plants". American Journal of Botany 82: 596-606
- Rice, W. R. (1984). " Sex chromosomes and the evolution of sexual dimorphism". Evolution. 38: 735–742.
- Rice, W. R. (1986). " On the instability of polygenic sex determination: the effect of sex-specific selection". Evolution. 40: 633–639.
- Rice, W. R. (1987a). " Genetic hitchhiking and the evolution of reduced genetic activity of the Y sex chromosome". Genetics. 116: 161–167.
- Roy, R. P. and Roy, P. M. (1971). " Mechanism of sex determination in *Coccinia indica*". J. Ind. Bot. Soc. 50:391–400.
- Sakamoto, K., Abe, T., Matsuyama, T., Yoshida, S., Ohmido, N., Fukui, K. and Satoh, S. (2005). "RAPD markers encoding retrotransposable elements are linked to the male sex in *Cannabis sativa* L.". Genome 48: 931–936.
- Sakamoto, K., Akiyama, Y., Fukui, K., Kamada, H. and Satoh, S. (1998). "Characterization, genome size and morphology of sex chromosomes in hemp (*Cannabis sativa* L.)". Cytologia 63: 459–464.
- Sakamoto, K., Akiyama, Y., Fukui, K., Kamada, H. and Satoh, S. (1998). "Characterisation, genome size, and morphology of sex chromosome in hemp (*Cannabis sativa* L.)". Cytologia 63: 459-464
- Sakamoto, K., Ohmido, N., Fukui, K., Kamada, H. and Satoh, S. (2000). "Site-specific accumulation of a LINE-like retrotransposon in a sex chromosome of the dioecious plant *Cannabis sativa*". Plant Mol. Biol. 44: 723–732.
- Sakamoto, K., Ohmido, N., Fukui, K., Kamada, H. and Satoh, S. (2000). "Site-specific accumulation of a LINE-like retrotransposon in a sex chromosome of a dioecious plant, *Cannabis sativa* L.". Plant. Mol. Biol. 44:723-732
- Sakamoto, K., Shimomura, K., Komeda, Y., Kamada, H. and Satoh, S. (1995). "A male-associated DNA sequence in a dioecious plant, *Cannabis sativa* L.". Plant Cell Physiol. 36:1549-1554
- Samantaray, S., Geetha, K. A., Hidayath, K. P. and Maiti, S. (2010). "Identification of RAPD markers linked to sex determination in guggal [*Cammiphora wightii* (Arnott.) Bhandari]". Plant Biotechnol. Rep. 4: 95–99.
- Sanchez-Vilas, J., Turner, A., and Pannell, J. R. (2011). "Sexual dimorphism in intra- and inter-specific competitive ability of the dioecious herb *Mercurialis annua*". Plant Biol. 13: 218–222.
- Santos, J.K. (1923). "Differentiation among chromosomes in *Elodea*". Bot. Gaz. 75: 42-59
- Santos, J.K. (1942). "Determination of sex in *Eloda*". Bot. Gaz. 77: 353-376
- Sarkar, D.D., Datta, K.B. and Sen, R. (1987). "Cytomorphology of some wild and cultivated numbers of *Trichosanthes* L. Cytologia 52: 405-417
- Sarkar, D.D. and Datta, K.B. (1988). "Cytological basis of sex expression in *Trichosanthes* L.". Cytologia 53(3): 475-483
- Sarkar, S. (1956). "Sex chromosome in palm". Genet. Iber. 9: 133-142
- Scotti, I., and Delph, L. F. (2006). "Selective trade-offs and sex-chromosome evolution in *Silene latifolia*". Evolution 60: 1793–1800.
- Seefelder, S., Ehrmaier, H., Schweizer, G. and Seigner, E. (2000). "Male and female genetic linkage map of hops, *Humulus lupulus*". Plant Breed. 119: 249–255.
- Semerikov, V., Lagercrantz, U., Tsarouhas, V., Ronnberg-Wastljung, A., Alstrom-Rapaport, C. and Lascoux, M. (2003). "Genetic

- mapping of sex-linked markers in *Salix viminalis* L.”. *Heredity* 91: 293–299.
- Sharma, A., A. and Chattopadhyay, D. (1991). “Sex determination in dioecious species of plants”. *J. Bot. Taxon. Geobot.* 102: 29–55.
- Sharma, A., Zinta, G., Rana, S. and Shirko, P. (2010). “Molecular identification of sex in *Hippophae rhamnoides* L. using isozyme and RAPD markers”. *For. Stud. Chin.* 12: 62–66.
- Sharma, A., Zinta, G., Rana, S. and Shirko, P. (2010). “Molecular identification of sex in *Hippophae rhamnoides* L. Using isozyme and RAPD markers”. *For. Stud. Chin.* 12: 62–66
- Shiba, H., Iwano, M., Entani, T., Ishimoto, K., Shimosato, H., Che, F. S. et al. (2002). “The dominance alleles controlling self incompatibility in *Brassica* pollen is regulated at RNA level”. *Plant Cell* 14: 491–504.
- Shibata, F., Hizume, M. and Kuroki, Y. (1999). “Chromosome painting of Y chromosomes and isolation of a Y chromosome-specific repetitive sequence in the dioecious plant *Rumex acetosa*”. *Chromosoma* 108: 266–270.
- Shibata, F., Hizume, M. and Kuroki, Y. (2000). “Differentiation and the polymorphic nature of the Y chromosomes revealed by repetitive sequences in the dioecious plant, *Rumex acetosa*”. *Chromosome Res.* 8: 229–236.
- Shibu, M. P., Ravishankar, K. V., Anand, L., Ganeshaiyah, K. N. and Shaanker, U. (2000). “Identification of sex-specification DNA markers in the dioecious tree, nutmeg (*Myristica fragrans* Houtt)”. *PGR Newslett.* 121: 59–61.
- Shirkot, P., Sharma, D. R. and Mohopatra, T. (2002). “Molecular identification of sex in *Actinidia deliciosa* var. *deliciosa* by RAPD markers”. *Sci. Hortic.* 94: 33–39.
- Siljak-Yakovlev, S., Benmalek, S., Cerbah, M., Coba de la Pena T., Bounaga, N., Brown, S.C. and Sarr, A. (1996). “Chromosomal sex determination and heterochromatin structure in date palm”. *Sex. Plnt. Reprod.* 9: 127–132
- Siljak-Yakovlev, S., Benmalek, S., Cerbah, M., Coba de la Pena, T., Bounaga, N., Brown, S. C. and Sarr, A. (1996). “Chromosomal sex determination and heterochromatin structure in date palm”. *Sex Plant Reprod.* 9: 127–132.
- Sinoto, Y. (1929). “Chromosome studies in some dioecious plants, with special reference to the allosomes”. *Cytologia* 1: 109–191
- Siroky, L., Lysak, M. A., Dolezel, J., Kejnovsky, E. and Vyskot, B. (2001). “Heterogeneity of rDNA distribution and genome size in *Silene* spp.”. *Chromosome Res.* 9: 387–393.
- Siroky, L., Lysak, M.A., Dolezel, J., Kejnovsky, E. and Vyskot, B. (2001). “Heterogeneity of rDNA distribution and genome size in *Silene* spp”. *Chromosome Res.* 9: 387–393
- Skaletsky, H., Brown, L. G., Kuroda-Kawaguchi, T., Minx, P. J., Cordum, H. S., Hillier, L. et al. (2003). “The male-specific region of human Y chromosome is a mosaic of discrete sequence classes”. *Nature* 423: 825–837.
- Smith, B. W. (1964). “The evolving karyotype of *Rumex hastatulus*”. *Evolution* 18: 93–104.
- Smith, R.W. (1937). “Notes on the cytology and distribution of the Dioscoreaceae”. *Bull. Torrey Bot. Club* 64: 189–197
- Sondur, S. N., Manshardt, R. M. and Stiles, J. I. (1996). “A genetic link-age map of papaya based on randomly amplified polymorphic DNA markers”. *Theor. Appl. Genet.* 93: 547–553.
- Sondur, S.N., Manshardt, R.M. and Stiles, J.I. (1996). “A genetic linkage map of papaya based on randomly amplified polymorphic DNA markers”. *Theor. Appl. Genet.* 93: 547–553
- Sousa, A., Fuchs, J. and Renner, S. S. (2013). “Molecular cytogenetics (FISH, GISH) of *Coccinia grandis*: a ca. 3 myr-old species of cucurbitaceae with the largest Y/autosome divergence in flowering plants”. *Cytogenet. Genome Res.* 139: 107–118.
- Sousa, A., Fuchs, J. and Renner, S.S. (2013). “Molecular cytogenetics (FISH, GISH) of *Coccinia grandis*: a ca. 3 myr-old species of Cucurbitaceae with the largest Y/autosome divergence in flowering plants”. *Cytogenet. Genome Res.* 139: 107–118
- Spada, E., Caporali, G., Marziani, G., Portaluppi, P., Restivo, F.M., Tassi, F. et al. (1998). “A genetic map of *Asparagus officinalis* based in integrated RFLP, RAPD, and AFLP molecular markers”. *Theor. Appl. Genet.* 97: 1083
- Spada, E., Caporali, G., Marziani, G., Portaluppi, P., Restivo, F. M., Tassi, F. et al. (1998). “A genetic map of *Asparagus officinalis* based on integrated RFLP, RAPD and AFLP molecular markers”. *Theor. Appl. Genet.* 97: 1083.
- Spielman, M., Vinkenoog, R., Dickinson, H. G. and Scott, R. J. (2001). “The epigenetic basis of gender in flowering plants and mammals”. *Trends Genet.* 17: 705–711.
- Spigler, R. B., Lewers, K. S. and Ashman, T. L. (2011). “Genetic architecture of sexual dimorphism in a subdioecious plant with a proto-sex chromosome”. *Evolution* 65: 1114–1126.
- Spigler, R. B., Lewers, K. S., Johnson, A. L. and Ashman, T. L. (2010). “Comparative mapping reveals autosomal origin of sex chromosome in octoploid *Fragaria virginiana* J.”. *Hered.* 101: 107–117.
- Spigler, R. B., Lewers, K. S., Main, D. S. and Ashman, T. L. (2008). “Genetic mapping of sex determination in a wild strawberry, *Fragaria virginiana*, reveals earliest form of sex chromosome”. *Heredity* 101: 507–517.

- Stchlik, I. and Blattner, F.R. (2004). "Sex specific SCAR markers in the dioecious plant *Rumex nivalis* (Polygonaceae) and implications for the evolution of sex chromosome". *Theor. Appl. Genet.* 108: 238-242
- Steflova, P., Steflova, P., Tokan, V., Vogel, I., Lexa, M., Macas, J. et al. (2013). "Contrasting patterns of transposable element and satellite distribution on sex chromosomes (XY1Y2) in the dioecious plant *Rumex acetosa*". *Genome Biol. Evol.* 5: 769–782.
- Stehlik, I. and Blattner, F. R. (2004). "Sex-specific SCAR markers in the dioecious plant *Rumex nivalis* (Polygonaceae) and implications for the evolution of sex chromosomes". *Theor. Appl. Genet.* 108: 238–242.
- Steinemann, S. and Steinemann, M. (2005). "Y chromosome borne to be destroyed". *BioEssays* 27: 1076–1083.
- Steven, J. C., Delph, L. F. and Brodie, E. D. 3<sup>rd</sup>. (2007). "Sexual dimorphism in the quantitative-genetic architecture of floral, leaf and allocation traits in *Silene latifolia*". *Evolution* 61: 42–57.
- Tanurdzic, M. and Banks, J. A. (2004). "Sex-determining mechanisms in land plants". *Plant Cell* 16: 561–571.
- Telgmann-Rauber, A., Jamsari, A., Kinney, M. S., Pires, J. C. and Jung, C. (2007). "Genetic and physical maps around the sex-determining M-locus of the dioecious plant *Asparagus*". *Mol. Genet. Genomics* 278: 221–234.
- Tenaillon, M. I., Hufford, M. B., Gaut, B. S. and Ross-Ibarra, J. (2011). "Genome size and transposable element content as determined by high throughput sequencing in maize and *Zea luxurians*". *Genome Biol. Evol.* 3: 219–229.
- Terauchi, R. and Kahl, G. (1999). "Mapping of the *Dioscorea tokoro* genome: AFLP markers linked to sex". *Genome* 42: 752–762.
- Testoli, R., Cipriani, G. and Costa, G. (1995). "Sex segregation ratio and gender expression in the genus *Actinidia*". *Sex. Plant. Reprod.* 8: 129-132
- Testolin, R., Cipriani, G. and Costa, G. (1995). "Sex segregation ratio and gender expression in the genus *Actinidia*". *Sex Plant Reprod.* 8: 129–132.
- Testolin, R., Huang, W. G., Messina, R., Vecchione, A. and Cipriani, G. (2001). "A kiwifruit (*Actinidia spp*) linkage map based on microsatellites and integrated with AFLP markers". *Theor. Appl. Genet.* 103: 30–36.
- Thomas, B. C., Pedersen, B. and Freeling, M. (2006). "Following tetraploidy in an *Arabidopsis* ancestor, genes were removed preferentially from one homologue leaving clusters enriched in the sensitive genes". *Genome Res.* 16: 934–946.
- Tracey, L. P., Koelewijn, H. P. and Dijk, P. J. (2004). "Identification of a male-specific AFLP marker in a functionally dioecious fig, *Ficus fulva* Reinw. ex Bl. (Moraceae)". *Sex Plant Reprod.* 17: 17–22.
- Turner, J. M. A. (2007). "Meiotic sex chromosomes inactivation". *Development* 134: 1823–1831.
- Uchida, W., Matsunaga, S., Sugiyama, R., Shibata, F., Kazama, Y., Miyazawa, Y. et al. (2002). "Distribution of interstitial telomere-like repeats and their adjacent sequences in a dioecious plant, *Silene latifolia*". *Chromosoma* 111: 313–320.
- Urasaki, N., Tokumoto, M., Tarora, K., Ban, Y., Kayano, T., Tanaka, H. et al. (2002). "A male and hermaphrodite specific RAPD marker for papaya (*Carica papaya* L.)". *Theor. Appl. Genet.* 104: 281-285
- Urasaki, N., Tokumoto, M., Tarora, K., Ban, Y., Kayano, T., Tanaka, H. et al. (2002). "A male and hermaphrodite specific RAPD marker for papaya (*Carica papaya* L.)". *Theor. Appl. Genet.* 104: 281–285.
- Vanburen, R. and Ming, R. (2013). "Dynamic transposable element accumulation in the nascent sex chromosomes of papaya". *Mob. Genet. Elements* 3: e23462.
- vanDoorn, G. S. and Kirkpatrick, M. (2010). "Transitions between male and female heterogamety caused by sex-antagonistic selection". *Genetics* 186: 629–645.
- Volz, S. M. and Renner, S. S. (2008). "Hybridization, polyploidy, and evolutionary transitions between monoecy and dioecy in *Bryonia* (Cucurbitaceae)". *Am. J. Bot.* 95: 1297–1306.
- Vyskot, B. (1999). "The role of DNA methylation in plant reproductive development In C.C Ainsworth [ed.], Sex determination in plants". BIOS Scientific Publishers, Oxford, UK: 101-120
- Vyskot, B. and Hobza, R. (2004). "Gender in plants: sex chromosomes are emerging from fog". *Trends Genet.* 20: 431–438.
- Vyskot, B., Araya, A., Veuskens, J., Negrutiu, I. and Mouras, A. (1993). "DNA methylation of sex chromosomes in a dioecious plant, *Melandrium album*". *Mol. Gen. Genet.* 239: 219–224.
- Wai, C. M., Ming, R., Moore, P. H., Paull, R. E. and Yu, Q. (2010). "Development of chromosome-specific cytogenetic markers and merging of broken linkage groups in papaya". *Trop. Plant Biol.* 3: 171–181.
- Wang, J., Na, J. K., Yu, Q., Gschwend, A. R., Han, J., Zeng, F. et al. (2012). "Sequencing papaya X and Yh chromosomes reveals molecular basis of incipient sex chromosome evolution". *Proc. Natl. Acad. Sci. USA* 109: 13710–13715.
- Wellmer, F., Riechmann, J. L., Alves-Ferreira, M. and Meyerowitz, E. M. (2004). "Genome-wide analysis of spatial gene expression in *Arabidopsis* flowers". *Plant Cell* 16: 1314–1326.
- Westergaard, M. (1958). "The mechanism of sex determination in dioecious flowering plants". *Adv. Genet.* 9 : 217–281.

- Wilkinson, J. (1944). "The cytology of *Salix* in relation to its taxonomy". *Ann. Bot. (N.S)* 8: 269-284
- Winge, O. (1923). "On sex chromosomes, sex determination and preponderance of females in some dioecious plants". *Comptes rendus des travaux du laboratoire Carlsberg* 15: 1-26
- Wolf, D. E., Satkoski, J. A., White, K. and Rieseberg, L. H. (2001). "Sex determination in the androdioecious plant *Datisca glomerata* and its dioecious sister species *D. cannabina*". *Genetics* 159: 1243–1257.
- Wu, X., Wang, J., Na, J. K., Yu, Q., Moore, R. C., Zee, F. *et al.* (2010). "The origin of the non-recombining region of sex chromosomes in *Carica* and *Vasconcellea*". *Plant J.* 63: 801–810.
- Wu, X., Wang, J., Na, J.K., Yu, Q., Moore, R.C., Zee, F. *et al.* (2010). "The origin of non-recombining region of sex chromosome in *Carica* and *Vasconcellea*". *Plant J.* 63: 801-810
- Yakbov, B., Barazani, O. and Goland-Goldhirsh, A. (2005). "Combination of SCAR primers and touchdown-PCR for sex identification in *Pistacia vera* L.". *Sci. Hortic.* 103: 473-478
- Yakubov, B., Barazani, O. and Golan-Goldhirsh, A. (2005). "Combination of SCAR primers and touchdown- PCR for sex identification in *Pistacia vera* L.". *Sci. Hortic.* 103: 473–478.
- Yamada, I. (1943). "The sex chromosome in *Cannabis sativa*". Report of the Kihara Institute for Biological Research 2: 64-68
- Yamato, K. T., Ishizaki, K., Fujisawa, M., Okada, S., Nakayama, S., Fujishita, M. *et al.* (2007). "Gene organization of the liverwort Y chromosome reveals distinct sex chromosome evolution in a haploid system". *Proc. Natl. Acad. Sci. USA* 104: 6472–6477.
- Yang, Z., El Aidi, J., Ait-Ali, T., Augur, C., Teller, G., Schoentgen, F. *et al.* (1998). "Sex-specific marker and trans-zeatin ribosidase in female annual mercury". *Plant Sci.* 139: 93–103.
- Ye, D., Installe, P., Ciuperescu, D., Veuskens, J., Wu, Y., Salesses, G. *et al.* (1990). "Sex determination in the dioecious *Melandrium*. I. First lessons from androgenic haploids". "Sex Plant Rep. 3: 179–186.
- Yin, T., Difazio, S. P., Gunter, L. E., Zhang, X., Sewell, M. M., Woolbright, S. A. *et al.* (2008). "Genome structure and emerging evidence of an incipient sex chromosome in *Populus*". *Genome Res.* 18: 422–430.
- Yu, Q., Hou, S., Feltus, F. A., Jones, M. R., Murray, J. E., Veatch, O. *et al.* (2008). "a Low X/Y divergence in four pairs of papaya sex-linked genes". *Plant J.* 53: 124–132.
- Yu, Q., Hou, S., Hobza, R., Feltus, F. A., Wang, X., Jin, W. *et al.* (2007). "Chromosomal location and gene paucity of the male specific region on papaya Y chromosome". *Mol. Genet. Genomics* 278: 177–185.
- Yu, Q., Navajas-Perez, R., Tong, E., Robertson, J., Paul, H., Moore, P.H. *et al.* (2008). "b Recent origin of dioecious and gynodioecious Y chromosomes in papaya". *Trop. Plant Biol.* 1: 49–57.
- Zhang, T. and Tan, D. Y. (2008). "Adaptive significances of sexual system in andromonoecious *Capparis spinosa* (Capparaceae)". *J. Syst. Evol.* 46: 861–873.
- Zhang, X., Feng, B. Q., Zhang, D., Altman, N. and Ma, H. (2005). "Genome-wide expression profiling and identification of gene activities during early flower development in *Arabidopsis*". *Plant Mol. Biol.* 58: 401–419.
- Zhang, Y. H., Di Stilio, V. S., Rehman, F., Avery, A., Mulcahy, D. and Kesseli, R. (1998). "Y chromosome specific markers and the evolution of dioecy in the genus *Silene*". *Genome* 41: 141–147.
- Zhou, Y., Wang, X. and Zhang, X. (2011). "Development and application of SRAP markers for the identification of sex in *Buchloe dactyloides*". *Euphytica* 181: 261-266
- Zluvova, J., Georgiev, S., Janousek, B., Charlesworth, D., Vyskot, B. and Negruțiu, I. (2007). "Early events in the evolution of the *Silene latifolia* Y chromosome: male specialization and recombination arrest". *Genetics* 177: 375–386.
- Zluvova, J., Janousek, B., Negruțiu, I. and Vyskot, B. (2005). "Comparison of the X and Y chromosome organisation in *Silene latifolia*". *Genetics* 170: 1431–1434.
- Zluvova, J., Zak, J., Janousek, B. and Vyskot, B. (2010). "Dioecious *Silene latifolia* plants show sexual dimorphism in the vegetative stage". *BMC Plant Biol.* 10: 208.
- Zuk, J. (1963). "An investigation on polyploidy and sex-determination within the genus *Rumex*". *Acta Socx. Bot. Pol* 32: 5-67