

# Cytotaxonomy and evolutionary trend in some species and varieties of *Oryza*

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The genus *Oryza* to which the cultivated rice belongs, comprises of a number of species. It belongs to the tribe of grasses known as Oryzaceae. The genus *Oryza* comprises of 23 species of which 21 are wild and 2 cultivated. The cultivated species are *O. sativa* in the tropics and *O. glaberrima* in West Africa. Due to its wide range of variations, especially habit, height, size and colour of grain, panicle pattern and flowering time of the different varieties of rice there is a belief that the cultivated rice is of polyphyletic origin.

The origin of cultivated rice is a subject of great controversy. It has been accepted generally that rice originated in India, Burma, Indo-China and S. China.

The present study was undertaken to find out the probable evolution of the species and varieties on the basis of karyotype analysis.

## Materials

The following seven species and four varieties were taken for the present investigations.

1. *O. awtraUcnsis* Domin
2. *O. eichengeri* Peter
3. *O. glaberrima* Steud
4. *O. minuta* Pres).
5. *O. officinalis* Wam ex Walt
6. *O. perennix* Moench
7. *O. saliva* Lin
  - (a) „ Var. Rupsail
  - (b) „ Var. Chinsurah Boro
  - (c) „ Var. Zuiho
  - (d) „ Var. Fukoku.

The above species are all annual except *O. perennis* which is perennial. They are terrestrial grasses, loosely or compactly tufted leaf blades usually lae and linear. The genus *Oryza* is characterised by the presence of small similar or dis-similar 1-3 flowered spikelets, reduced scale like sterile lemmas, minute glumes, 6 stamens, ovary glabrous, style short and free and stigma feathery tightly adhering to the fertile lemma and palea. Fruit is a caryopsis.

The distribution of these species is as follows:

1. *O. saliva* India
2. *O. glaberrima* West Africa.
3. *O. perennis* Asia, Africa and America
4. *O. minuta* Malay Peninsula, Philip-  
pines, Sumatra, Java and Borneo.
5. *O. eichingeri* East Africa, Tange-  
nika and Uganda.
6. *O. officinalis* India, Assam and  
Burma.
7. *O. australiensis* Australia.

Of these the first two species are culti-  
vated and the rest are wild species of *Oryza*.

#### Method and Technique

The seeds were germinated on moist filter  
papers in petri-dishes. For the mitotic  
study, root tips were collected from 2-3 days  
old seedlings and fixed in conc. HC1 and  
rectified spirit (1: 3) for 1 hour. The mat-  
erial was transferred to 45% acetic acid for  
5 minutes and then to 1% acetocarmine and  
squashed in iron acetocarmine after 6 hours.  
For permanent preparations, chromic-for-  
malin (4:6) was used. The staining was  
done with crystal violet, following LaCour's  
longer schedule.

#### I. (a). *O. sativa* var. 'Rupsait'

The diploid number is 24 of which 2 pairs are satellited. The complement consists of  
4 pairs of medium and 8 pairs of short chromosomes. It consists of the following:

Medium with median constriction	2 pairs
Medium fl <sup>A</sup> th submedian constriction	2 pairs
Short ,j median ,,	2 pairs
,, ,, submedian ,,	6 pairs

The ratio between the median to submedian position of kinetochore is 4:8. The  
length of the chromosome varied with in a range of 1.4  $\mu$  to 2.6 $\mu$  and the total length of  
the haploid complement is 21.6  $\mu$ .

#### 1- (b). *O. saliva* var 'Chinsurah Boro '

The diploid number is 24 of which 2 pairs are satellited. The analysis of idiogram  
is as follows:

Medium with median constriction	2 pairs
submedian	5 pairs

For meiotic studies, the flower  
buds of the right stage were fixed in  
Carnoy's fluid and smeared in iron acetocar-  
mine. Nucleolar studies were made by fix\*  
ing the root tips in acetic alcohol and stained  
in Feulgen-Fast green.

#### OBSERVATIONS

##### Chromosome number

In the present investigations, the '2n  
was found to be 24 except in 2 species i.e.,  
*O. minuta* and *O. eichingeri* in which it was  
48.

##### Mitosis

The somatic division in the species has  
been found to be normal. The chromo-  
somes are fairly small ranging from 1.0  $\mu$   
to 3.5  $\mu$  in length. In the karyotype studies  
the chromosomes are divided into 3 cate-  
gories according to the length; long medium  
and short. Chromosomes whose length is  
3 " and above are long, between 3 and 2  $\mu$   
medium and below 2  $\mu$  as short chromo-  
somes.

Short	„	median	„	1 pair
„	„	submedian	„	4 pairs

The ratio between the median to submedian position of kinetochore is 3:9. The length of the chromosomes ranged from 1.7  $\mu$  to 2.8  $\mu$ , and the total length of the haploid complement is 24.8  $\mu$ .

1. (c) *O. saliva* var. *ZuihO*: —

The  $2n$  number is 24 in this variety **also**. There are 2 pairs of satellited chromosomes. The following are the details of the karyotype.

Medium with median" constriction		1 pair
„ „ submedian „	»	2 pairs
Short „ median „		2 pairs
„ „ submedian „		7 pairs

The ratio of median to submedian position of Kinetochore is 3:9. The chromosome length varied between 1.0  $\mu$  to 2.3  $\mu$  and the total length of the haploid complement is 19.6  $\mu$ .

1. (d) *O. saliva* var. *Fukokn*:—

The  $2n$  number is 24 of which 4 are satellited. The complement comprises of one pair of long, 4 pairs of medium and 7 pairs of short chromosomes. The analysis of the idiogram is as follows:

Long with median constriction		1 pair
Medium „ submedian „		4 pairs
Short „ median „		2 pairs
Short „ submedian „		5 pairs

The haploid complement length is 23.2  $\mu$  and the chromosome length varied from 1.3  $\mu$  to 3.0  $\mu$ .

2. *O. glaherrirna*

No. of chromosomes ( $2n$ )	=	24
No. of satellited chromosomes		2 pairs
Medium with median constriction		1 pair
Medium with submedian „		2 pairs
Short „ inedian „		3 pairs
Short „ submedian „		6 pairs

Ratio of position of inedian and submedian constriction has been found to be 4:3.

Length of the chromosome 1.0  $\mu$  to 2.8  $\mu$

Total length of haploid complement 20.3  $\mu$

3 *O. australiensis*

Number of chromosomes ( $2n$ )	24
Number of satellited chromosomes	2 pairs

Long with submedian constriction	1 pair
Medium „ median „	2 pairs
Medium „ submedian „	7 pairs
Short „ submedian „	2 pairs
Ratio of median and submedian position of kinetochores	2:10
Length of the chromosome	1.5 to 3.3 u

4. *O. offidnalis*

Number of chromosomes (2n)	24
Number of satellited chromosomes	2 pairs
Long with submedian constriction	3 pairs
Medium „ median „	1 pair
Medium „ submedian „	7 pairs
Short „ median „	1 pair
Ratio of position of kinetochores	2:10
Length of the chromosome	1.8 « to 3.5 ft
Total length of the haploid complement	30.5/«

5. *O. perrenuis*

No. of chromosomes (2n)	24
No. of satellited chromosomes	2 pairs
Medium with submedian constriction	3 pairs
Short „ median „	5 pairs
Short „ submedian „	4 pairs
Ratio bet. the median and submedian position of kinetochores	5:7
Length of the chromosome	1.5 u to 6 P
Total length of the haploid complement	22.6 P

6. *O. minuta*

No. of chromosomes (2n)	48
No. of satellited chromosomes	4 pairs
Medium with median constriction	2 pairs
Medium „ submedian „	4 pairs
Short „ median „	6 pairs
Short „ submedian „	12 pairs
Ratio of median to submedian position of kinetochores	8:16
Length of the chromosome	1.2 u to 2.8 u
Total length of the haploid complement	43.2 P

7. *O. eschingeri*

No. of chromosomes	(2n)	48
No. of satellited chromosomes		4 pairs
Medium with median constriction		2 pairs
Medium with submedian	„	4 pairs
Short	„ median „	3 pairs
Short	„ submedian „	15 pairs
Ratio bet. median and submedian position of kinetochore		5:19
Length of the chromosome	1.2 " to 2.5 "	
Total length of the haploid complement		42.6 "

The anaphasic and telophasic behaviour of all the species are normal.

## Meiosis

Meiosis in the 5 species of *Oryza* were studied namely *O. xativa*, *O. glaberrima*, *O. australiensis*, *O. minuta* and *O. eichingeri*. The pollen mother cell is comparatively bigger than the somatic cells. The chromosome behaviour of the different species was found to be similar. There are 12 bivalents in the case of the diploid species and 24 bivalents in the polyploid ones, in the metaphase I stage of meiosis, Anaphase I and Telopliase I are normal in all cases, Each diad enters the second division cycle separately but simultaneously resulting in the formation of tetrads and ultimately into pollen grains.

## DISCUSSION

1. Speciation in the genus *Oryza*

Cytotaxonomical investigations in *Oryza* have been meagre for a critical interpretation of the origin of the genus.

Since the pioneering work of Navaschin (1934), it has been an accepted fact that in each species there is a definite individuality in their somatic chromosomes with regard to their morphology.

The three aspects of the genus constituting its evolutionary history are:—

- Time of origin
- Place of origin
- Mode of origin

## Time of origin

The origin of this genus dates back to time immemorial. Decandolle (1886) shows its antiquity in China as early as 2800 B. C. and from there spread to India. Roxburgh and Thompson support his contention.

## Place of origin

Watt (1892) reviewed all the previous work and put forth evidence from philology to suggest that rice cultivation originated in S. India, spread to North and from there across the Himalayas to the East in 3000 B. C.

## Mode of origin

The history of the origin of rice is a much disputed subject. It is however accepted that the primitive ancestors of the genus closely resembled grasses in their creeping habit and perennial nature. During the course of evolution, the following changes seemed to have occurred.

- i. From prostrate habit to erect,
- ii. Perennial nature to annual.
- iii. Pigmented colour of seed or pericarp to white.
- iv. the shedding nature of seed to non-shedding nature.

Roschevicz (1931) opines that the majority of cultivated rice has originated from the wild rice *O. sativa* var *spontaneae*, its varieties and mutants and that the small fruited cultivated rice has probably evolved from *O. minuta*. He has suggested that the rice is of a polyphyletic origin, Hutchinson and Ramiah (1938) oppose the view of the origin of cultivated rice from *O. minuta* on the ground that the latter is a tetraploid.

Backer (1946) suggests the possibility of *O. fatua* being a probable ancestor of *O. sativa* which is *O. perennis* according to the description. Chatterjee (1951) considers *O. sativa* var *fatua* as the probable ancestor of the cultivated rice. Sauer (1947) proposes that the rice was originally a weed in taro fields and that in weeding it was replanted elsewhere, and *O. sativa* var *fatua* and *O. perennis* have contributed to the origin of cultivated rice.

The present study of the cytology of the species of this genus affords evidence on evolution and speciation on three different ways.

- i. Length of chromosome
- ii. Morphology of chromosome
- iii. Number of chromosomes.

A closer examination of the karyotype of the seven species reveals differences in the morphology of the chromosomes including

the position of the centromere, nature of the satellites and the length of the chromosomes (Table I).

Again there are variations in the number of long, medium and short chromosomes in each complement. Levitsky (1931) has studied the specialisation of the karyotype in the tribe *Heleboreae*. He enunciated the phenomenon that the primitive basic complement is composed of chromosomes with similar length and with median or almost median constriction. From this, metacentric chromosomes and asymmetrical karyotypes have been derived through the gradual loss of the length of chromosome resulting in the shifting of the position of centromere from median to submedian.

Regarding the length of the chromosomes there are two aspects to be considered.

- (a) the relative size between the different chromosomes of the same set, and
- (b) the absolute size of the complement.

De launey (1926) for the first time postulated the significance of the length of the chromosomes in the evolution of plants. According to him during the course of evolution of plants, there has been a progressive reduction in the size of the chromosomes. He studied the phylogenetic reduction in the size of the chromosomes in the genus *Muscari*, where the more specialised species showed, smaller absolute length of the chromosomes. Babcock and Cameron (1935) reported a similar progressive reduction in the chromosome length in *Crepis* accompanied by the annual growth habit as well as the reduction of plant parts. Among the angiosperms this phenomenon is also reported in *Caryophyllaceae*, *Juncaceae*, *Cyperaceae* and *Liliaceae*. Among the ferns, the more primitive

TABLE

Genus <i>Oryza</i>		2n: number	Length of Chromosome			Morphology of Chromosome		Length of the Chromosome		
Species	Varieties		Long	Medium	Short	Media-nally constricted	Sub-media-nally constricted	Length of chromosome ( $\mu$ )	Total length of the haploid complement ( $\mu$ )	
1.	<i>Oryza perennis</i>	-	24	-	3 pairs	9 pairs	5 pairs	7 pairs	1.5 to 2.6	22.6
2.	<i>O. glaberrima</i>	-	24	-	3 "	9 "	4 "	8 "	1.0 to 2.8	20.3
3a.	<i>O. sativa</i> var Rupsail	-	24	-	4 "	8 "	4 "	8 "	1.5 to 2.6	21.6
3b.	<i>O. sativa</i> var Chirusurah Boro	-	24	-	7 "	5 "	3 "	9 "	1.7 to 2.8	24.8
3c.	<i>O. sativa</i> var Fukoku	-	24	1 pair	4 "	7 ;	3 "	9 "	1.3 to 3.0	23.2
3d.	<i>O. sativa</i> var Zuiho	-	24	-	3 "	9 "	3 "	9 "	1.0 to 2.3	19.6
4.	<i>O. officinalis</i>	-	24	3 pairs	8 "	t pair	2 "	10 "	1.8 to 3.5	30.5
5.	<i>O. australiensis</i>	-	24	1 pair	9 "	2 pairs	2 "	10 "	1.5 to 3.3	26.6
6.	<i>O. eichingeri</i>	-	48	-	6 "	18 "	5 "	19 "	1.2 to 2.8	42.6
7.	<i>O. minuta</i>	-	48	-	6 "	18 "	8 "	16 "	1.2 to 2.8	43.2

families like *Osmundaceae*. and *Hymenophyllaceae* have relatively large chromosomes while the small chromosomes are found in vegetatively reduced and reproductively specialised heterosporous *Salvinaceae* (De Litardiere, 1921 ).

Length of the chromosomes

The total length of the somatic chromosomes in seven species has been investigated and is represented in the table I. A critical analysis of these reveals that the species of this genus are characterised by the presence of distinctively large or short chromosome complements. Thus the species studied can be divided into two groups.

- (a) *Species where the total length of haploid complement is more than 25<sup>u</sup>*
  - i. *O. officinalis* \ diploid 1
  - ii. *O. australiensis* ) Wild
  - iii. *O. eichingeri*) tetraploid )
  - iv. *O. minuta* I
  
- (b) *Species where the length of the haploid complement is less than 25<sup>u</sup>*
  - i. *O. perennis* Wild
  - ii. *O. glaberrima*
  - iii. *O. sativa* var, Rupsail  
var. Chinsurah Boro  
var. Zuiho I cultivated  
var. Fukoku

Applying De launey's hypothesis (1, c.) on the phenomenon " Chromosomen verkürzung", i. c., the progressive reduction in the absolute length of the chromosome in the evolutionary scale it will be seen from the present study that the first group has as a rule longer chromosomes than the second group suggesting that the first group is primitive. It is worthwhile to mention that all the species of the first group are wild forms, while all the species in the second group are cultivated ones except

*O. perennis* which is wild and from which cultivated ones are supposed to have evolved

Morphology of chromosomes

The phylogenetic significance of the position effect of the centromere was first propounded by Levitsky ( 1931) in *Heleboreae*. He enunciated the phenomenon that the primitive basic complement is composed of chromosomes with similar length and with median or almost median constriction. The reduction in the length of the chromosome implied the loss of chromatin from one or both the arms of a chromosome. This results in the shifting of the centromere from median to submedian position. This type of wide diversity in the karyotype in a single family was found in *Liliaceae* which includes some of the most asymmetric examples found in plants which are definitely specialised morphologically, the most striking examples being *Yucca*, and *Agave* (Mc. Kelvey and Sax 1933 and Whitaker 1934).

Stebbins (1951) stated that - the plants with asymmetrical karyotypes are usually specialised morphologically, sometimes in vegetative parts, sometimes in flowers or fruits and sometimes in both" and that " the evidence indicates that the karyotype of the original unspecialised progenitors of most families of plants were essentially symmetrical"

A clear study of the ratios of the median to submedian position of the centromere divides the species studied into two groups in terms of the total length of the haploid complement,

∴. *Chromosome length of 25<sup>u</sup> and above.*

- a. Ratio 8:16 *O. minuta*
- b. Ratio 5:19 *O. eichingeri*
- L. Ratio 2:10 *O. officinalis*
- d. Ratio 2:10 *O. australiensis*



- it. *Chromosome length below 25 $\mu$*
- a. Ratio 5:7 *O. perennis*
- b. Ratio 4:8 *O. sativa* var Rupsail  
*O. glaberimma*
- c. Ratio 3:9 *O. sativa* var. *Chinsurah*  
*Boro*
- ” ” var. *Fokuku*
- ” ” var. *Zuiho*

From the above it is seen that the highest number of median constriction is present in species composed of chromosome having a 5:7 ratio. According to Levitsky's hypothesis it is reasonable to assume that this species is the most primitive and from which a phylogenetic displacement of the centromere, 4:8, 8:16, and 3:9 ratios has been attained.

#### Chromosome numbers

Variations in the chromosome numbers are known to be widely responsible for speciation in plants. These changes are brought about by either

- (a) aneuploidy—addition or loss of one or more chromosomes

or

- (b) polyploidy—increase in multiples of the 'n' number—

Examples of such a mode of specialisation are numerous. The families characterised by a high frequency of polyploidy are *Polygonaceae*, *Crassulaceae*, *Rosaceae*, *Malvaceae*, *Araliaceae*, *Gramineae* and *Iridaceae*. Stebbins (1938) opines that on the average the highest percentage of polyploids are found in perennial herbs, a small proportion in annuals and lowest in woody plants.

Although in *Gramineae*, the occurrence of polyploidy is very common, the species of

the genus *Oryza* are conspicuous by the constancy of the chromosomes. Only in six cases, the occurrence of polyploids has so far been reported. Of these (*O. minuta* and *O. eichingeri*) have been studied in the present investigation.

#### *O. minuta*

This species has been studied by a number of workers of whom Kuwada (1910), Selim (1930) and Nandi (1936) are most important. Morphologically this species comes nearer to *O. sativa* and *O. officinalis*. According to Nandi (1936), the *minuta* complement consists of 2 sets of chromosomes, one being larger and the other smaller and he came to the conclusion that it is an allopolyploid species arising as a result of the union of *O. sativa* and *O. officinalis* wherein either unreduced gametes were involved or there has been subsequent doubling of chromosomes perhaps to overcome cross-infertility. Nandi however, was not able to locate the parental chromosomes in *O. minuta* complement either on the basis of their length or morphology. He even did not compare the somatic chromosomes of the so called synthetic counterpart. It was therefore, decided to undertake investigation of the three species and try to locate as many of the parental pairs as possible in an attempt to trace the evolution on more scientific grounds.

From the karyotype analysis, it has been seen that *O. minuta* is composed of 12 medium, and 36 short chromosomes of which 32 are submedianly and 16 medianally constricted. This is compared with the complement of *O. sativa* and *O. officinalis* which have the following constitution.

	Saliva	Officinalis	Minuta
Size of chromosomes	4 medium	3 long	
	8 short	8 medium 1 short	6 medium 18 short
Morphology of chromosomes	4 medianally constricted	2 medianally constricted.	8 medianally constricted
	8 submedianally constricted	10submedianally constricted	16submedianally constricted
			nally constricted

Comparing these and the size of the satellited chromosomes, it is seen that the suggestion of one complete '2n' complement of *O. sativa* and *O. officinalis* being present in *O. minuta* is not tenable.

The absence of the knowledge of any species or set of species from which *O. minuta* could be derived either as a direct polyploid or as allopolyploid makes the problem of its origin more difficult.

According to Stebbins (1951), natural polyploids must resemble their related diploids more or less closely. Since the size and structure of the species is not comparable either with the degree of polyploidy or the parents assigned to it by Nandi (l. c.) which are both bigger in size, it appears reasonable to assume that at least one of the species involved in the origin of *O. minuta* is either a dwarf or a prostrate type. The fact that the species has an aliopolyploid, rather than the autopolyploid origin is confirmed by the absence of two morphologically similar sets of chromosomes in the

haploid complement as well as the absence of multivalents. On the morphological evidence, the possibility of *O. perennis* being one of the parents cannot be ruled out.

### *O. eichingeri*

This species is also a higher polyploid. Cytological studies were undertaken for the first time on this species. On comparing this species with *O. glaberrima*, it was found that there is a gross similarity between the somatic complement of the two species. There are 6 medium and 18 short chromosomes in *O. glaberrima* and 12 and 36 respectively in *O. eichingeri*. Again *O. glaberrima* has 4 medianally and 8 submedianally constricted chromosomes where as the corresponding number in *O. eichingeri* is 5 and 19 respectively. On studying the morphology, it was found that only 6 pairs of *O. eichingeri* are duplicated chromosomes which are comparable to 6 pairs of *O. glaberrima*, suggesting thereby that this species is not a direct polyploid from *O. glaberrima*. This suggests that more than one species are involved in the origin of *O. eichingeri*,

one of which may be *O. glaberrima*. This is also supported by the evidence of the geographical distribution of the two species which happens to be in Africa.

Assuming, on this evidence, *O.eichingeri*'s an allopolyploid with the following complement (AAAA BB CC) 6- 48, where AA stands for the part of the complement which is duplicated. This species must have been evolved from the union of unreduced gametes or doubling of a hybrid of two species, half of whose complement is common. The origin may therefore be represented as follows;—

$$\begin{array}{l} (AA\ BB)_3 \\ (AACC)_3 \end{array} \quad (AAAABB\ CC)_6$$

On the basis of this hypothesis, the other parent of *O.eichingeri* must have had a common ancestry with *O. glaberrima* and this species must have been a fairly advanced type with the complement composed of 1 medianally and 11 submedianally constricted chromosomes. Unfortunately many members of the *glaberrima* stock have not been investigated to locate such a parent.

### Scheme of evolution in the genus

On the evidence from the morphology, taxonomy and karyotype, chromosome number and polyploidy, discussed above, it will appear that more extensive investigation in the remaining and particularly the more primitive species is necessary to find out the evolutionary trend in the genus. The present attempt is to correlate the species investigated so as to suggest a tentative scheme of evolution in the genus to help the future workers to find the missing links.

The scheme proposed from the present investigations has been drawn on the basis of the study of the chromosomes of 7 species and 4 varieties of *Oryza*. It is generally accepted that the primitive ancestors of the genus very closely resembled grasses in their creeping habit and perennial nature. The scheme takes into account the habit of the plant, the number of chromosomes, their length and morphology.

Table II illustrates the tentative scheme of evolution in the genus *Oryza*.

The parent stock gives rise to two distinct lines or stocks.

#### (1) *Perennis* stock

This group is characterised by the more primitive characters such as the length of the chromosomes and preponderance of medianally constricted chromosomes in the complement and the perennial habit of the species. Assuming that the 'parent stock' was composed of one or more species with chromosomes of almost uniform size and largely with median constriction, the most primitive condition is obtained in *O.perennis* where 5 out of 12 chromosomes are medianally constricted. Whether this species arose directly from the parent stock or through intermediate species remains yet to be determined.

From *O. perennis*, evolution has proceeded along two lines, one giving rise to *O. glaberrima* (cultivated rice of Africa) through the loss of chromatin and the shifting of the centromere from median to submedian, the latter proceeding to contribute to the formation of a polyploid *O.eichingeri*.

The other line has given rise to the *saliva* stock (cultivated rice of India, Japan and China) which again branches into 2, namely

*Indica* and *japonica* lines. The identity of these 2 lines is confirmed not only by the decrease in length of the chromosomes but also on the nucleolar organiser. Jones and Longely (1941) consider that *indica* and *japonica* represent varieties of the same origin but since they have been grown under different environmental conditions for a long time, there has been an accumulation of gene mutations and gene rearrangements within the chromosomes.

This therefore shows that *O. perennis* is the parent of the cultivated species of rice and confirms the observations made by Nandi (1936), Parthasarathy (1938), Sampath and Rao (1951) and Pathak (1951).

## (2) *Officinalis* stock

This stock is the other branch originated from the parent stock. This line is characterised by very long chromosomes despite being advanced with regard to the position of the centromere, the ratio being 2:10. But *O. officinalis* is morphologically primitive because of its perennial habit. *O. officinalis* seems to have separated early and in turn given rise to *O. australiensis* through reduction in the length of the complement and change to annual habit. *O. officinalis* may also have contributed in the origin of *O. eichingeri* which remains to be confirmed.

The *Officinalis australiensis* line therefore represent specialised line whose further evolution has apparently ceased, as the latter species has become endemic to Australia and the chances of its mixing or contributing towards the formation of new species is limited due to geographical reasons.

The only species which could not be adequately interpreted is *O. minuta*. Its origin is still controversial.

This is purely a tentative scheme and has to be modified when other species of this genus have been investigated. This is just an attempt to show the possible lines on which evolution has taken place.

## SUMMARY

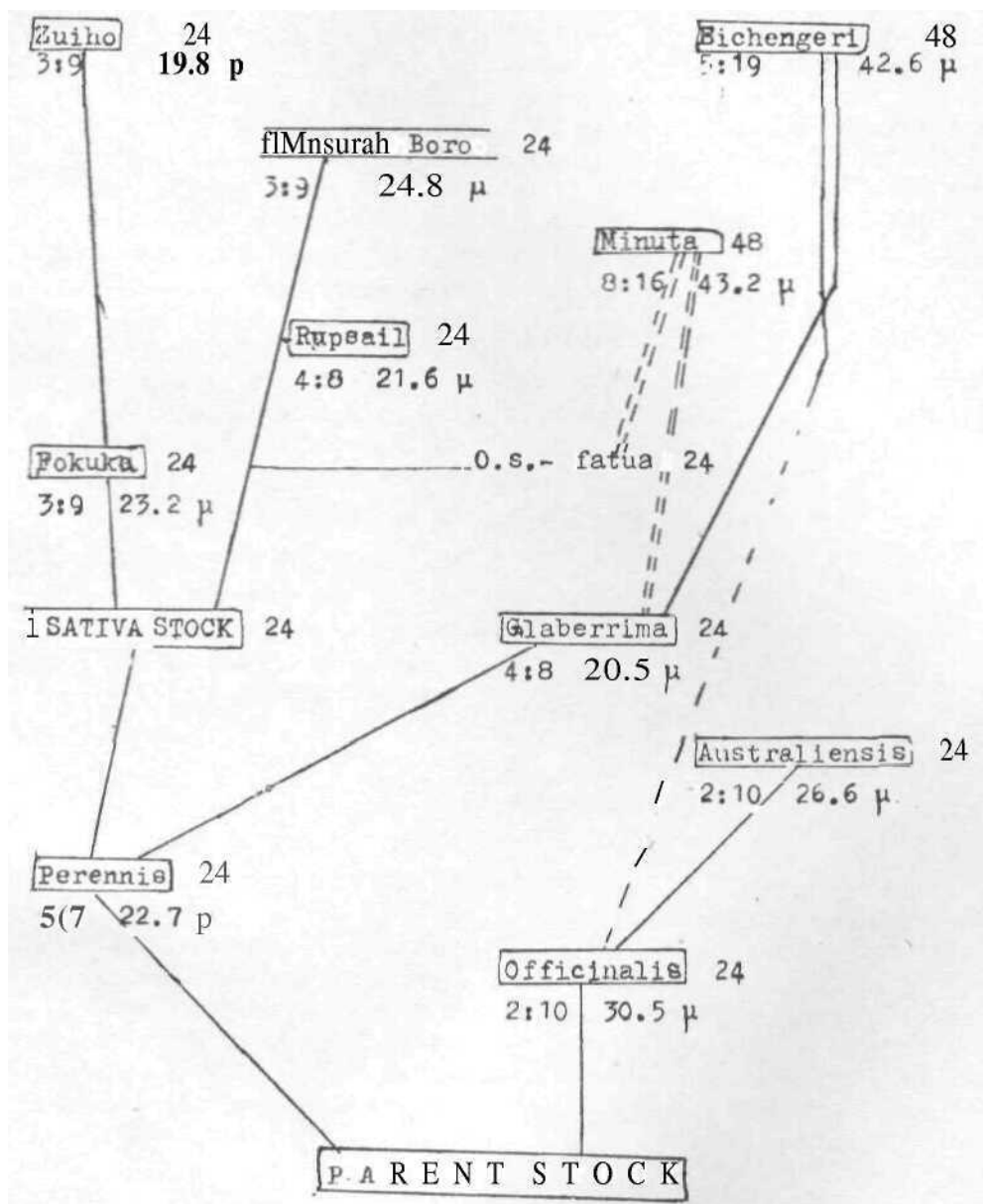
A cytological study of seven species and four varieties of *Oryza* has been carried out. The species investigated are *O. glaberrima*, *O. perennis*, *O. australiensis*, *O. officinalis*, *O. xativa* (varieties 'Rupsail' 'Chinsurah Boro' 'Zuiho', and 'Fukoku') *O. eichingeri* and *O. minuta*, *O. saliva* and *O. glaberrima*, are the cultivated species of the genus while the rest are wild. All the species investigated are diploids ( $2n=24$ ) except *O. minuta* and *O. eichingeri* which are tetraploids ( $2n=48$ ) Taxonomically these species are identified on the basis of lemma, ligule, spikelets, awn, stamens and their habit.

A special technique for the cytological study was evolved using a mixture of Cone, HCl and rectified spirit (1:3) as the fixative for root tips, the fixed materials being stained in 1% aceto-carmine after washing in 45% acetic acid.

The somatic chromosomes have been analysed and tabulated on the basis of the morphology and the total length of the haploid complement. The chromosomes are fairly small in size ranging from 1.0  $\mu$  to 3.5  $\mu$  only in length. Both the length of the individual chromosomes and the total length of the haploid complement have been used as the index of the proximity of the species. Other cytological variations like number of chromosomes etc. were also studied.

The meiosis of five species viz. *O. sativa*, *O. glaberrima*, *O. australiensis*, *O. minuta* and

A Tentative Scheme of Evolution in Genus ORYZA



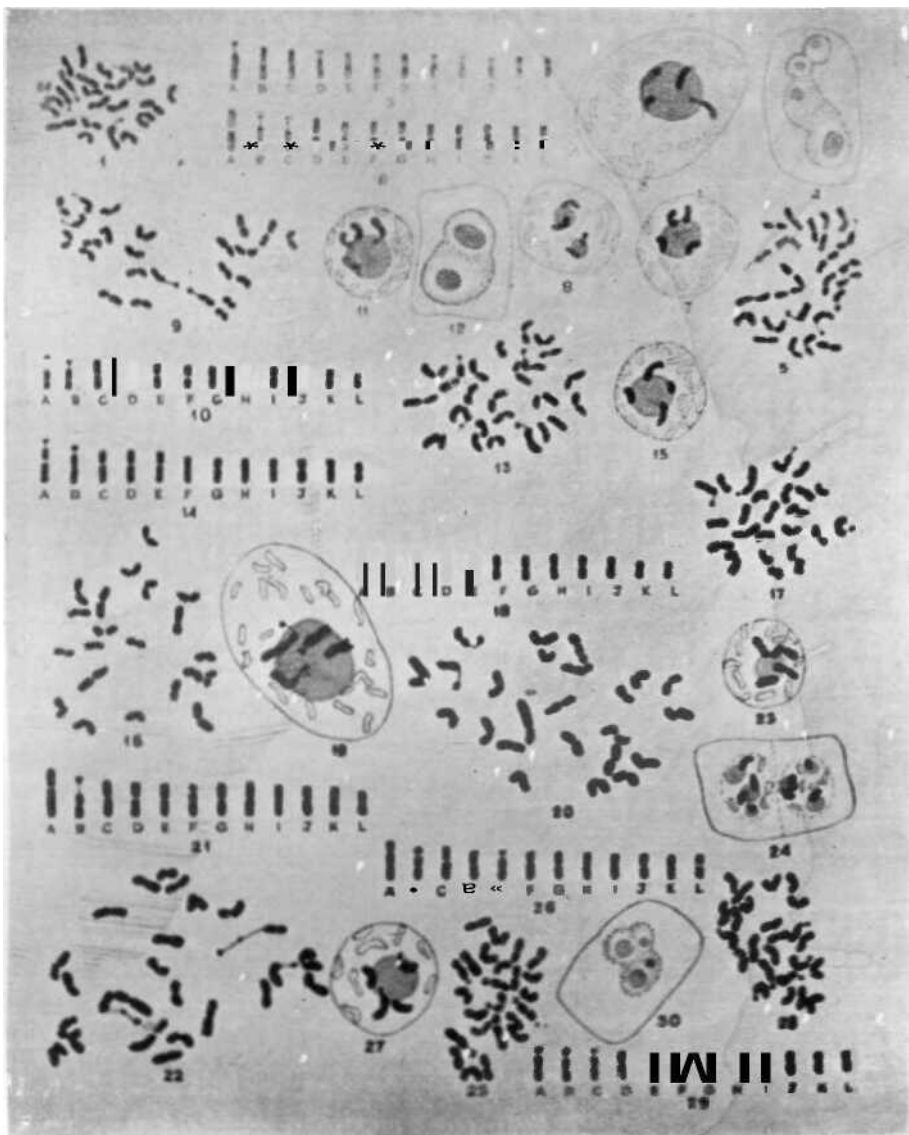
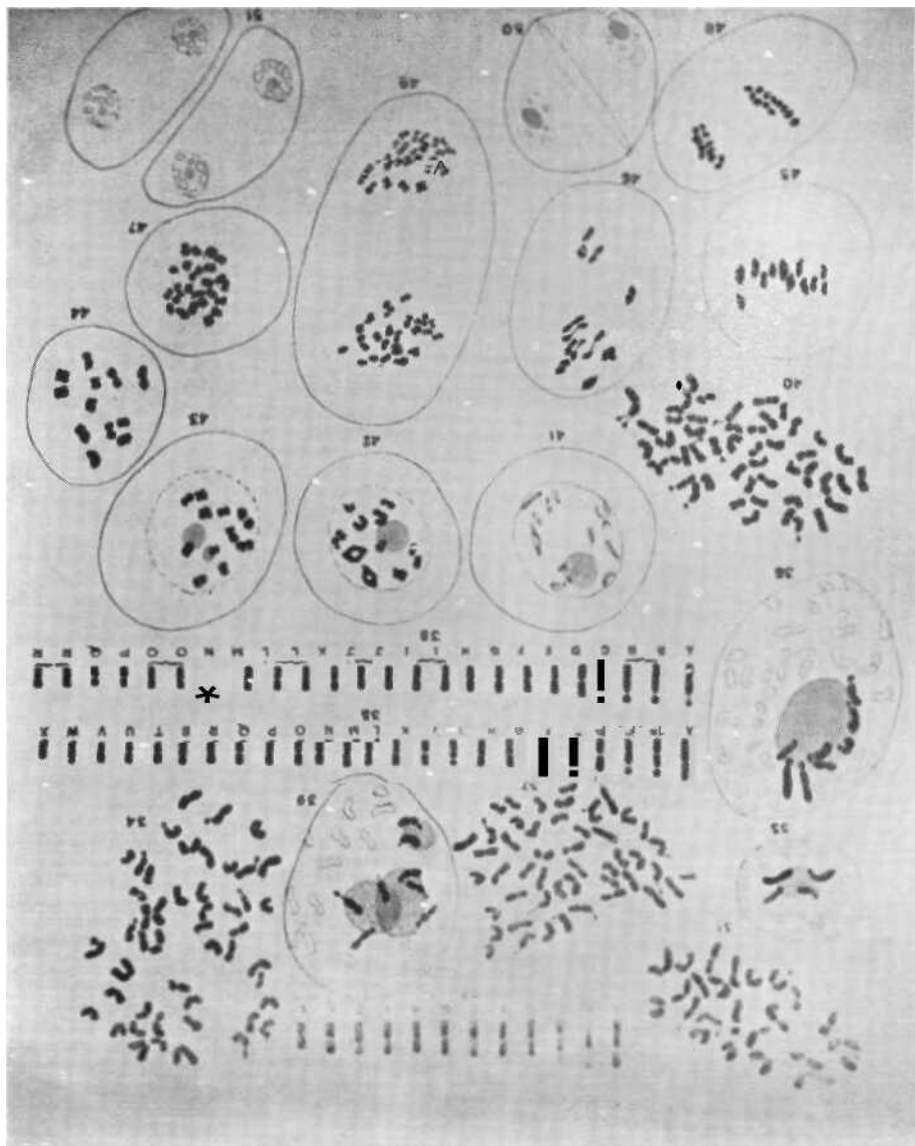


PLATE i



*O. eichingeri* has also been investigated. The nucleoli and nucleolar chromosomes have been studied in detail in all the species.

The speciation of the genus has been discussed on the basis of the morphology and behaviour of the chromosomes. This criterion was applied to determine the origin of the two tetraploid species, i. e., *O. minuta* and *O. eichingeri*. It has been concluded that *O. glaberrima* is probably one of the parents in the origin of *O. eichingeri*.

A tentative scheme of evolution and speciation in the genus *Oryza* has been suggested on the evidence obtained from the study of karyotypes. From parent stock, two different 'stocks' seem to have emerged viz., the 'Perennis' and the 'Officinalis' stocks. The 'Perennis' stock in turn gave rise to 2 sub-branches, one of which gave rise to *O. glaberrima* (cultivated in Africa)

and the other to *O. sativa* (cultivated in India, Japan and China). The 'Officinalis' stock is characterised by very long chromosomes despite the presence of relatively advanced characters. This stock seems to have separated early and has in turn given rise to *O. australiensis* which has become endemic in Australia.

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| 28. | <i>O. perennis</i><br>(Madagascar type) | Polar view of somatic metaphase.                                    |
| 29. |   | Idiogram of the haploid complement.                                 |
| 30. |   | Prophase nucleus with 4 nucleoli.                                   |
| 31. | <i>O. officinalis</i>                   | Polar view of somatic metaphase.                                    |
| 32. |   | Idiogram of the haploid complement.                                 |
| 33. |   | Prophase nucleus with 4 chromosomes attached to a single nucleolus. |
| 34. | <i>O. minuta</i>                        | Polar view of somatic metaphase                                     |
| 35. | 11 18                                   | Idiogram of the haploid complement.                                 |
| 36. | 91                                      | Prophase with 1 nucleolus and 8 chromosomes attached to it.         |
| 37. | <i>O. eichingeri</i>                    | Polar view of the somatic metaphase                                 |
| 38. | 19 "                                    | Idiogram of the haploid complement.                                 |
| 39. |   | Prophase nucleus with 3 nucleoli and 8 nucleolar chromosomes.       |
| 40. | 91 "                                    | Somatic metaphase with 49 chromosomes.                              |
| 41. | <i>O. australiensis</i>                 | Diploetene stage showing 2 bivalent attached to one nucleolus.      |
| 42. | 99 "                                    | Late diplotene.   |
| 43. | 99 99                                   | Diakinesis with 2 bivalents attached to 2 nucleoli                  |
| 44. | <i>O. saliva</i>                        | Metaphase I showing 12 bivalents.                                   |
| 45. | <i>O. glaberrima</i>                    |   |
| 46. | <i>O. australiensis</i>                 |   |
| 47. | <i>O. minuta</i>                        | Metaphase I showing 24 bivalents                                    |
| 48. | <i>O. australiensis</i>                 | Anaphase I showing normal separation of the bivalents.              |
| 49. | <i>O. eichingeri</i>                    | Telophase I   |
| 50. | <i>O. sativa</i>                        | Telophase I showing the formation of 1hc diad                       |
| 51. | <i>O. eichingeri</i>                    | Telophase II.   |