SUMMARY AND CONCLUSIONS
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1. The present studies on the caryotypes of the reptiles have been undertaken because of the evolutionary importance of the group. An attempt has been made to consolidate the existing data and to add detailed information in as many species as possible. They serve as a prelude to the studies on species relationship and taxonomy.

2. The caryotypes in the various species under investigation are as follows:

**Family colubridae**

1. *Cereberus rhynchos* 2n=38 8Vs - 2 rods - 28 dots
2. *Ptyas mucosus* 2n=34 10Vs - 6 rods - 18 dots
3. *Natrix stolata* 2n=34 12Vs - 2 rods - 20 dots
4. *Xenochrophis piscator* (Quilon) 2n=36 10Vs - 6 rods - 20 dots
5. *Xenochrophis piscator* (Agra) 2n=38 8Vs - 2 rods - 28 dots
6. *Boiga trigonata* 2n=44 4Vs - 18 rods - 22 dots

**Family viperidae**

7. *Bothrops carinata* 2n=36 10Vs - 6 rods - 20 dots

**Family Elapidae**

8. *Bungarus caeruleus* 2n=44 4Vs - 18 rods - 22 dots
9. *Naja tripidiane*  
Family *Trionchidae*

10. *Lissamyctes punctata*  
Family *Emydidae*

11. *Hardella thurgii*  
Family *Agamidae*

12. *Agama tuberculata*  
Family *Scincidae*

13. *Mabuya carinata*  
Family *Varanidae*

14. *Varanus monitor*  
Family *Varanidae*

3. Seasonal activity in the gonads of reptiles is highly pronounced. There is a marked variation in the seasonal activity of the gonads in the species obtained from the North - and South-India.

In North the gonidal activity is at its peak during August and September whereas in the South it is in December. This again varies from species to species.
4. There is a marked periodicity of the mitotic division in the gonads. Mitosis is most abundant in the animals dissected at night. This holds good for the majority of the species, whereas in some the actively dividing gonads could be procured even in the afternoon.

5. Since the clumping of the micro-chromosomes handicaps analysis, a pretreatment method was evolved. Colchicine 0.25% and hypotonic (Sodium citrate 0.96% or the Pannett and Compton) in the ratio of 1:2 gives excellent results as this minimises clumping to a considerable degree. In the somatic tissues colchicine injection followed by the hypotonic treatment gave unequivocally good results.

6. The course of mitosis and meiosis is fairly normal in most species. The micro-chromosomes reveal precocious separation in most species. Sex chromatin was wanting in the interphase nuclei. Snakes in general have more interstitial chiasmata and they persist till the late metaphase.

7. Chromosome lengths for the various chromosome pairs have been measured in all the species. Percentage lengths for the pairs and other details too have been added.
8. The diploid number of chromosomes for Cerberus rhynchos is 38 and the chromosomes can be divided into three categories on the basis of size. Clumping is very much pronounced in this species. Some of the micro-chromosomes appear to be metacentric and carry more than one chiasma. The interstitial chiasmata are retained till the very late metaphase. The caryotype of this species has a marked superficial resemblance to that of Xenochrophis piscator (Agra).

9. The caryotype of Ptyas mucosus comprises 34 chromosomes and differs from the one described earlier by Bhatnagar (1960). Whereas Bhatnagar (1960) described only 8 metacentric, ten have been recognised during the present studies. The fundamental number of arms for Ptyas mucosus is 44 unlike 42 described by Bhatnagar. The micro-chromosomes in this species reveal poor stainability.

There is an early terminalization of the chiasmata in the bivalents number 5, 6, 7 and 8. Some of the nuclei are characterized by a very low chiasma frequency in the macro-bivalents.

Interkinesis is present. In the prophase nuclei a heteropycnotic body can be recognized which is never bipartite.
10. The caryotype of *Natrix stolata* was studied by Bhatnagar (1960a) from U.P. where it consists of 10Vs, 6 rods and 20 dots.

The caryotype of this species from Chandigarh comprises 12 Vs, 2 rods and 20 dots. The two types can, however, be approximately derived from each other through simple fusions or fissions.

11. The two populations of *Xenochrophis piscator*, separated by a long distance, revealed a marked diversity in the caryotypes and mitotic and meiotic behaviour. The caryotypes in the two populations are 8Vs, 2 rods and 28 dots (Agra) and 10Vs, 6 rods and 20 dots (Quilon) respectively. The two caryotypes, however, can be approximately converted into each other by suggesting a hypothetical intermediate, in which there occurred fusions.

12. Caryotype in *Boiga trigonata* is most aberrant with the highest 2n=44 constituted by 22 macro- and 22 micro-chromosomes. Four of the chromosomes are metacentric. The first largest pair is, however, acrocentric.

13. The diploid number and the fundamental number for the *Bohitis carinatus* is 36 and 46 respectively. There is nothing atypical about this species.
14. The diploid number of chromosomes for *Bungarus caeruleus* is 44.

The somatic tissues in the female reveal inconstancy. The diploid complement can be divided into 22 macro- and 22 micro-chromosomes. There are two metacentric pairs in this species unlike the one described by Bhatnagar (1960b). Moreover, the second metacentric pair is heteromorphic, one of the partners being half the size of the other. The distinction between the macro- and micro-complement is distinct only during the pro-metaphase.

15. The caryotype in *Naia tripidiens* comprises 38 chromosomes which can be divided into two categories of macro- and micro-chromosomes.

Some of the individuals revealed aneuploid variations in the germ cells.

16. The diploid number for *Lissemys punctata* is 64.

The chromosomes of this species can be divided into three size groups. The pair number three in order of size is heteromorphic.

During meiosis some of macro-bivalents reveal a low chiasma frequency. In some of the nuclei, the
homologues of the bivalent number 4 are with no chiasmata and lie in close proximity. Tetraploid cells could be followed throughout mitosis and meiosis. Two types of tetraploid metaphase I plates were seen—one with the elements of usual thickness and the others with thin fragile elements having poor stainability. Animals dissected in winter and summer differed in their chiasma frequency.

17. The diploid garniture of Hardella thurwii comprises 50 chromosomes. They can be sorted into three size groups. The third largest pair, in order of size, is heteromorphic.

18. In both the males and females of Agama tuberculata, the caryotype comprises 34 chromosomes. They can be sorted into two categories. Pairs number 1 and 3 are with a satellite-like body.

19. In both the males and females of Mabuya carinata, the caryotype is again similar. The 2n is 30 which is perhaps the highest recorded for Scincidae. Some of the micro-chromosomes are metacentric.

20. The caryotype of Varanus monitor comprises
40 chromosomes 8 Vs - 8 rods and 24 dots, unlike that repeated by Bhatnagar (1959) who described 6 metacentrics for this very species. The second pair is nucleolar organizer. One of the micro-chromosome pairs is very small. Somatic tissues of the female revealed aneuploid cells.

21. Polyploidy is extremely common in the gonads of Cerberus rhynchops, Ptyas mucosus, Natrix stolata, Lissemys punctata and Mabuya carinata. Mostly the level of ploidy is tetraploidy but even higher polyploid nuclei were common in Natrix stolata and Cerberus rhynchops. Most of the tetraploid nuclei were seen only at the mitotic level. But in Lissemys punctata tetraploidy could be followed even during meiotic divisions.

However, no tetraploid metaphase II plates could be seen. Tetraploid nuclei of Natrix stolata revealed fragmentation. Such a high degree of the polyploid cells seem to be non-functional as no giant sperm was ever recorded.

22. Modal number

Ophidian caryotypes reveal a marked similarity in general which is all the more pronounced in the colubrids. Six species of this family studied afford a good example of the uniform caryotypes within the
families and genera. A review of literature allows the conclusion that there is a definite modal number for the snakes. The modal diploid number for the colubrids and viperids is 36. Because of the limited data available no modal number could be assigned to the elapids. No modal number could be arrived at in Varanidae, Scincidae, and turtles but there are two modal numbers for Agamidae viz. 34 and 46.

23. **Modal caryotype**

Nakamura (1935a) put forth the concept of the modal caryotype for snakes which is 10 V's - 6 rods and 20 dots. Although most species do not fall under the limit of this modal caryotype, they can be derived or converted into the modal caryotype by simple fusions and fissions, structural changes followed by fusions and fissions and or by the deletions and duplications.

Although the modal caryotypes have been suggested for Scincidae (Nakamura, 1931), Makino and Momma (1949) most species do not fall under the limit of this modal caryotype.

In Agamidae there are at least two modal caryotypes which confirm the results of Makino and Momma (1949) most species do not fall under the limit of
24. **Morphometric data**

Caryotype rigidity in the family and allied genera is also evident by the morphometric data, of which the Colubridae is a good example. Caryotype similarity in Colubridae was established by the total length of the pairs, percentage length of the pairs, percentage macro-micro-complement, ratio of the micro-to macro-complement, biskaryograms and the composite idiograms.

25. Nakamura (1935a) and Matthey (1949, 51) suggested the concept of the fundamental number of arms. According to these authors, the Robertsonian forces (Robertson, 1916) are highly operative on the caryotypes of reptiles with the result that although a large number of structural changes are taking place but the fundamental number remains fairly constant. The present studies reveal that the fundamental number is fairly constant in snakes especially of the family, Colubridae and Viperidae where it is 46. Amongst lizards the fundamental number is fairly constant only in Agamidae, where again it is 46. There is no fixed fundamental number in turtles, scincids and elapids.

26. **Polymorphism**

A distinct chromosomal polymorphism was observed in the two populations of *Matrix stolata* and *Xenochrophis*
piscator separated by long distances and other ecological and geographical barriers. The polymorphic forms can be approximately derived from each other by simple Robertsonian (Robertson, 1916) fusions and at times by certain structural shifts followed by fusions. Polymorphism is perhaps a species adaptation to a specific niche and a step in evolutionary series. Populations that breed true and are cytologically distinct should be raised to the level of sub species.

27. **Inconstancy**

Inconstancy in the chromosome number has been observed in *Bungarus caeruleus* and *Varanus monitor* (somatic tissues) and *Naja tripidians* (germ cells). Whereas it seems to be the inherent property of the somatic cells the latter is the result of repeated non-disjunction.

28. There is the suggestion of a satellite in the 11nd largest pair of the chromosomes in *Varanus monitor* and in the first and third large pairs in *Agama tuberculata*.

29. **Micro-chromosomes**

In most species during meiosis, the micro-chromosomes appear by the late cycle of condensation and
differentiation. They have the invariable tendency
to agglutinate which is most pronounced in the
colubrids. They appear to be acrocentric except in
Cerebrus rhynchops and Mabuya carinata where some of
them are metacentric.

30. A pair of very small micro-chromosome in
Ptyas micusus and Varanus monitor has been labelled
as the 'm' pair. Its poor stainability perhaps
reflects the small amount of DNA. It can also be a
step towards the loss of a pair which though existing
is genetically inert.

31. Sex chromosome mechanism

Sex chromosome mechanism is a fairly confusing
problem in reptiles. In most of the species under
investigation the male is homomorphic sex. A distinct
female heterogamety could be recorded only in a
single case of Xenochrophis piscator (Agra). There
is a suggestion of male heterogamety in turtles.
Morphologically distinct sex chromosomes seem to be
lacking in lizards under investigation (Agama tuber-
culata, Mabuya carinata and Varanus monitor).

32. Chiasma control in reptiles

Chiasma frequency in the macro-complements of
the various species was analysed for their statistical correlations.

a) When the inter-cellular and inherent variance was calculated in the whole nuclei, the chiasma frequency in most species is positively correlated except in *Xenochrophis piscator* and *Cereberus rhynchos*, where again there seems to be no competition between the bivalents for the chiasma frequency.

b) When the metacentric bivalents were considered separately in the various species, a positive correlation was observed in most of the species. A negative correlation amongst the metacentric bivalents was seen only in the two species but this was non-significant.

c) The acrocentric bivalents in most species are positively correlated. Negative correlation, when present, is insignificant.

d) When the chiasma frequency correlations between the two groups is made in various species, it is mostly positive, significant or non-significant. Negatively correlated chiasma frequency between the groups was recorded in a single case, *Lissemys* (L.C.F), but this is again non-significant.
e) As the correlation between the chiasma frequency of the bivalents is far more important than between the groups and cells, the correlation between bivalents was developed. Successive bivalents in the order of size, seldom compete; when, however, they compete, it is always the smaller bivalents.

f) To have an exact idea of the degree of correlation between the bivalents, regressions coefficient were calculated.

g) Competition between the bivalents for the chiasma frequency, as suggested by Mather (1936) seems to be lacking in the species under study. The chiasma frequency in most of the species is positively correlated. There might be a slight competition at the bivalent level, but it is quite insignificant to express itself at the cellular level. Chiasma control seems to operate through narrow limits and the so-called negative correlation is not the only method of control. It is difficult to pinpoint any single control mechanism, perhaps interference, biochemical release, chemical regulation and competition within narrow limits contribute towards the efficient mechanism of chiasma control.