

Web Table 1. Polyploidy in insects and vertebrates.

Columns: (a) Species (Family) listed alphabetically by order, family, genus, (b) degree of polyploidy, (c) mode of reproduction in polyploid forms, (d) mode of reproduction in closely related diploid forms, (e) reference.

Key to ploidy level: $3x$ = somatic triploidy (etc.); $2x^*$ = an ancient re-diploidized tetraploid (note that the extent of disomic inheritance is unknown in many species); / = species with multiple ploidy levels; auto = polyploids thought to be autopolyploid; allo = thought to be allopolyploid; mult = thought to have multiple origins; sing = thought to have a single origin.

Key to reproductive modes: P = parthenogenesis (automixis or apomixis); P_G = gynogenesis or pseudogamety (fertilization requires stimulation by sperm, which are not incorporated genetically); P_H = hybridogenesis (sperm contribute genetically to the zygote, but the paternal genome is lost sometime during development); D = sexual with dioecy/bisexuality (D_m = male heterogamety, D_f = female heterogamety, D_A = arrhenotoky, D_{TSD} = temperature sex determination); H = hermaphroditism.

Notes: A “?” is placed in entries where a source expressed reservation. Occasional cases are denoted by “(oc)”. Reports of a single polyploid individual are denoted by “(one)”; such cases are included because further sampling may reveal more extensive polyploidy. The table excludes somatic polyploidization, tumor-related polyploidization, induced or lab-reared polyploids, and reports of polyploid embryos or larvae. For vertebrates, closely related forms were assumed to be dioecious unless parthenogenetic relatives are known. Also for vertebrates, sex determination is listed only if it is known from members of the same family; if there is within-family variability in sex determination, sex determination is listed only when known for closely related species (15, 36).

Taxon	Ploidy Level	PolyploidRe pro.	Related Repro.	References
INSECTA				
Coleoptera [beetles]				
<i>Ptinus clavipes</i> f. <i>mobilis</i> (Ptinidae)	3x	P _G	D _m	42, 76
<i>Bromius (Adocus) obscurus</i> (Chrysomelidae)	2x/3x	P	D _m	42, 76
<i>Altica lazulina</i> (Chrysomelidae)	3x	P	D _m	69
<i>Calligrapha</i> spp. (Chrysomelidae)	4x (×6)	P	D _m	42
Curculionidae spp. [Weevils]	2x/3x (×7); 2x/3x/4x (×4); 2x/3x/5x; 2x/4x; 2x/4x/5x/6x; 3x (×23); 3x/4x (×3); 3x/5x; 4x (×7); 4x/5x; 5x; 4x/6x (sing)	P	D _m , P (oc)	42, 52, 72, 76
<i>Otiorrhynchus scaber</i>	(mult)			64
<i>Aramigus tessellatus</i>				52
Diptera [flies]				
<i>Ochthiphila polystigma</i> (Chamaemyiidae)	3x	P	P	42
<i>Limnophyes virgo</i> (Chironomidae)	3x	P	P, D	42
<i>Lundstroemia parthenogenetica</i> (Chironomidae)	3x	P	D	76
<i>Pseudosmittia</i> sp. (Chironomidae)	3x	P	P, D	76
<i>Phytomyza crassiseta</i> (Psychodidae)	2x/3x	P	P, D _m	10
<i>Psychoda parthenogenetica</i> (Psychodidae)	3x	P	D	42
<i>Cnephia mutata</i> (Simuliidae)	2x/3x	P	D _m	6
<i>Gymonopais</i> sp. (Simuliidae)	3x	P	D _m	42
<i>Prosimulium macropyga</i> (Simuliidae)	3x	P	D _m	42
<i>Prosimulium ursinum</i> (Simuliidae)	3x	P	D _m	42

Embioptera [web-spinners]				
<i>Haploembia</i> sp. (Oligotomidae)	2x/3x	P	P, D _m	8
Homoptera [scale insects, planthoppers]				
<i>Physokermes hemicryphus</i> (Coccidae)	2x/3x	P		42
<i>Muellerianella fairmairei</i> (Delphacidae)	3x	P _G		42
Hymenoptera [bees, sawflies]				
<i>Diprion simile</i> (Diprionidae)	4x _{female} /2x _{male} ?	D _A ,P	D _A	42
<i>Melipona quinquefasciata</i> (Apidae)	4x _{female} /2x _{male} ?	D _A	D _A	42
Lepidoptera [moths]				
<i>Solenobia fennicella</i> (Psychidae)	4x	P		42
<i>Solenobia lichenella</i> (Psychidae)	2x/4x	P	D _f	42
<i>Solenobia seileri</i> (Psychidae)	4x	P		42
<i>Solenobia triquetrella</i> (Psychidae)	2x/4x (auto, mult)	P	P, D _f	43
Orthoptera [grasshoppers, cockroaches]				
<i>Pycnoscelus surinamensis</i> (Blaberidae)	2x/3x (mult)	P	P, D _m	28
<i>Eublaberus distanti</i> (Blaberidae)	3x?	D _m ?	D _m	18
<i>Saga pedo</i> (Tettigoniidae)	4x	P	D _m	42
VERTEBRATES				
Chordata Two ancient genome duplications have been proposed (but see 68), with the most common proposal placing duplications before (~500MYA) and after (~430MYA) the divergence of jawless fish.	2x*?			4, 30, 53, 59
FISH				
Actynopterygii [ray-finned fishes]	2x*? (150-360 MYA)			4, 78
Acipenseriformes [paddlefish, sturgeons]				
<i>Scaphirynchus platorhynchus</i> (Acipenseridae)	4x		D	66
<i>Polyodon spathula</i> (Polyodontidae)	4x	D	D	66

Atheriniformes [silversides]				
<i>Menidia</i> sp. (Atherinidae)	2x/3x(oc)	P	P,D	24
Cypriniformes [suckers, loach, carp, minnows]				
<i>Barbatula barbatula</i> (f. <i>Noemacheilus barbatulus</i>) (Balitoridae)	2x/3x(one)		D	20
Catostomidae	2x* (~50 MYA)	D	D	66
<i>Botia</i> spp. (Cobitidae)	4x (×4)	D	D	62, 81
<i>Cobitis</i> sp. (Cobitidae)	2x/3x/4x (allo)	P _G	D	75
<i>Cobitis biwae</i> (Cobitidae)	2x/4x		D	66
<i>Misgurnus anguillicaudatus</i> (Cobitidae)	2x/3x(oc)/4x(oc)	D	D	5
<i>Misgurnus fossilis</i> (Cobitidae)	2x/4x		D	58, 60
<i>Barbodes</i> (<i>Spinibarbus</i>) spp. (Cyprinidae)	4x (×3)		D	81
<i>Barbus</i> spp. (Cyprinidae) Subgenus <i>Labeobarbus</i> is 6n; subgenus <i>Barbus</i> is an allotetraploid.	4x (×multiple); 6x	D	D	17
<i>Acrossocheilus sumatranus</i> (Cyprinidae)	4x		D	70
<i>Aulopyge hugelii</i> (Cyprinidae)	4x		D	46, 73
<i>Carassius auratus</i> (Cyprinidae) Secondary triploidy and tetraploidy within the tetraploid Cyprininae subfamily.	2x*/3x/4x (mult)	P _G	2n*=D _m	66, 67, 81
Cyprininae subfamily (Cyprinidae) Includes <i>Carassius</i> , <i>Carassioides</i> , <i>Cyprinus</i> , <i>Procypris</i> .	2x* (~16 MYA) (allo?)	D _m	D	41, 66, 81
<i>Opsariichthys uncirostris bidens</i> (Cyprinidae)	3x		D	46, 81
<i>Phoxinus eos-neogaeus</i> complex (Cyprinidae)	2x/3x (allo)	P _G , P _H	D	23, 31
<i>Rutilus alburnoides</i> complex (Cyprinidae) Triploid exhibits an unusual form of meiotic hybridogenesis.	2x/3x/4x (allo, mult)	D, P _H	D _f	3
Schizothoracinae subfamily (Cyprinidae) Includes <i>Diptychus</i> , <i>Schizothorax</i> .	4x	D	D	46
<i>Schizothorax</i> spp. (Cyprinidae) Triploids in the 4n Schizothoracinae.	6x (×6)	D	D	46
<i>Synocyclocheilus</i> spp. (Cyprinidae)	4x (×2)		D	81
<i>Tor</i> spp. (Cyprinidae)	4x (×3)		D	34
<i>Zacco platypus</i> (Cyprinidae)	3x		D	46, 81

Cyprinodontiformes [livebearers, mollies]				
<i>Poecilia</i> spp. (Poeciliidae)	3x (×3) (allo)	P _G	P _G ,D	66, 75
<i>Poeciliopsis</i> spp. (Poeciliidae)	3x (×3) (allo)	P _G	P _H ,D	66
Lepisosteiformes [lungfish]				
<i>Protopterus dolloi</i> (Protopteridae)	4x		D	74
Lepisosteiformes [gar]				
<i>Lepisosteus oculatus</i> f. <i>productus</i> (Lepisosteidae)	4x?		D	66
Perciformes [walleyes]				
<i>Stizostedion vitreum</i> (Percidae)	2x/3x(oc)		D	25
Salmoniformes [salmon, trout, char]				
Salmonidae. Multivalents still observed in some species; evidence for dominant-Y sex determination	2x* (auto?) (25-100 MYA)	D _m	D _m	2
Siluriformes [catfish]				
<i>Corydoras</i> , <i>Aspidoras</i> , <i>Brochis</i> spp. (Callichthyidae) Common ancestor inferred to be polyploid with at least two secondary polyploid events.	Various n	D	D	54, 55
<i>Clarias batrachus</i> (Clariidae)	2x/4x(oc)		D _f	56
<i>Heteropneustes fossilis</i> (Heteropneustidae)	1x/2x/3x/4x	D	D	57
AMPHIBIANS				
Anura [frogs, toads]				
<i>Bufo</i> sp. D (Bufonidae)	4x (allo?)	D _f	D _f	12
<i>Bufo boreas-punctatus</i> hybrids (Bufonidae)	2x/3x (oc) (allo)		D _f	26
<i>Bufo danatensis</i> (Bufonidae)	4x (allo?)	D _f	D _f	12, 47
<i>Bufo viridis</i> (Bufonidae)	2x/4x (allo, mult)	D _f	D _f	12, 48
<i>Hyla versicolor</i> (Hylidae)	4x (<0.5 MYA, auto?, sing)	D	D _m	12, 61
<i>Phyllomedusa tetraploidea</i> (Hylidae) 3x hybrids formed with <i>P. distincta</i> .	4x (auto?)	D	D _m	35
<i>Aphantophryne</i> (<i>Cophixalus</i>) <i>pansus</i> (Microhylidae)	4x	D	D	40
<i>Chiasmocleis leucosticta</i> (Microhylidae)	4x	D	D	37
<i>Ceratophrys dorsata</i> (Leptodactylidae)	8x (auto?)	D	D _m	12

<i>Ceratophrys ornata</i> (Leptodactylidae)	2x/8x (auto?)	D	D _m	12, 65
<i>Eleutherodactylus binotatus</i> (Leptodactylidae)	4x?	D	D _m	7
<i>Eupsophus vertebralis</i> (Leptodactylidae)	2x/3x(one) (auto?)		D _m	27
<i>Leiopelma hochstetteri</i> (Leiopelmatidae)	2x/3x(one) (auto)		D _f	33
<i>Odontophrynus americanus</i> (Leptodactylidae) 3x hybrid formed with <i>O. cultripes</i> .	2x/4x (auto?)	D	D _m	12, 63, 65
<i>Pleurodema bibroni</i> (Leptodactylidae)	4x (allo?)	D	D _m	12
<i>Pleurodema kriegi</i> (Leptodactylidae)	4x (allo?)	D	D _m	12
<i>Neobatrachus sudelli</i> (Myobatrachidae)	4x	D	D	45
<i>Neobatrachus sutor</i> (Myobatrachidae)	4x	D	D	45
<i>Silurana</i> (f. <i>Xenopus</i>) <i>epitropicalis</i> (Pipidae)	4x	D _f	D _f	16
<i>Xenopus</i> spp. (Pipidae) Common ancestor inferred to be tetraploid with at least two secondary polyploidizations.	2x* (~30 MYA); 4x (×5); 6x (×1) (allo?)	D _f	D _f	16, 38
<i>Dicroglossus occipitalis</i> (Ranidae)	2x/4x (allo?)	D	D	12
<i>Pyxicephalus delalandii</i> (Ranidae)	2x/4x (allo?)	D	D _f	12
<i>Rana</i> spp. (Ranidae)	2x/3x(oc) (×2)		D	32, 77
<i>Rana esculenta</i> (Ranidae)	2x/3x (allo)	P _H	D	12
Caudata [salamanders, newts, sirens]				
<i>Ambystoma</i> spp. (Ambystomidae)	2x/3x(oc)(×5) (auto, allo?)		D _f	44
<i>Ambystoma laterale-jeffersonianum</i> hybrid complex (Ambystomidae)	2x/3x/4x/5x (allo)	P _G , P _H (oc)	D _f	12, 13, 75
<i>Ambystoma laterale-texanum</i> hybrid complex (Ambystomidae)	2x/3x/4x (allo)	P _G	D _f	12
<i>Ambystoma</i> tri-hybrids of <i>jeffersonianum laterale</i> , <i>texanum</i> and/or <i>trigrinum</i> (Ambystomidae)	3x/4x (allo)		D _f	75
<i>Triton taeniatus</i> (Salamandridae)	2x/3x(one)		D _m	14
Sirenidae	2x*?	D	D	49
REPTILES				
Squamata [geckos, lizards, snakes]				
<i>Amphibolurus nobbi nobbi</i> (Agamidae)	2x/3x(one)		D	79

<i>Leiolepis triploida</i> (Agamidae)	3x	P	D	12
<i>Gehyra variegata</i> (Gekkonidae)	3x	P	D _f	12
<i>Hemidactylus garnotii</i> (Gekkonidae)	3x	P	D _f	12, 51
<i>Hemidactylus vietnamensis</i> (Gekkonidae)	3x	P	D _f	22
<i>Heteronotia binoei</i> complex (Gekkonidae)	2x/3x (allo, mult)	P	D _f	50
<i>Lepidodactylus lugubris</i> (Gekkonidae)	2x/3x (allo?, mult)	P	P, D _f	51
<i>Sceloporus</i> spp. (Iguanidae)	2x/3x (oc) (×2) (auto?)		D _m	19
<i>Lacerta</i> spp. (Lacertidae)	2x/3x(oc) (×multiple) (allo,auto)	P,D?	P,D _f	21, 39
<i>Cnemidophorus</i> species (Teiidae)	3x (×7); 2x/3x (×1) (allo)	P	D _m	75
<i>Ramphotyphlops braminus</i> (Typhlopidae)	3x? (allo?)	P	D	80

Chelonia [twist-necked turtle]

<i>Platemys platycephala</i> (Chelidae) Males have diploid testicular tissue regardless of somatic constitution.	2x/3x/4x/mosaics	D _{TSD} ?	D	9
--	------------------	--------------------	---	---

BIRDS

Galliformes [chicken, quail]

<i>Gallus domesticus</i> (Phasianidae)	2x/3x(oc)/4x(oc) (auto)		D _f	1, 11
--	-------------------------	--	----------------	-------

Psittaciformes [blue-and yellow macaw]

<i>Ara ararauna</i> (Aratingidae)	2x/3x(one) (auto)		D _f	71
-----------------------------------	-------------------	--	----------------	----

MAMMALS

Rodentia [red viscacha rat]

<i>Tympanoctomys barrerae</i> (Octodontidae)	4x	D _m	D _m	29
--	----	----------------	----------------	----

LITERATURE CITED IN WEB TABLE:

1. Abdel-Hameed F, Shoffner RN. 1971. Intersexes and sex determination in chickens. *Science* 172:962-964
2. Allendorf FW, Thorgaard GH. 1984. Tetraploidy and the evolution of salmonid fishes. In *Evolutionary Genetics of Fishes*, ed. BJ Turner, pp. 1-53. New York: Plenum Press
3. Alves MJ, Coelho MM, Collares-Pereira MJ. 1998. Diversity in the reproductive modes of females of the *Rutilus alburnoides* complex (Teleostei, Cyprinidae): A way to avoid the genetic constraints of uniparentalism. *Molecular Biology & Evolution*. 15:1233-1242
4. Amores A, Force A, Yan YL, Joly L, Amemiya C, *et al.* 1998. Zebrafish hox clusters and vertebrate genome evolution. *Science* 282:1711-4
5. Arai K, Matsubara K, Suzuki R. 1993. Production of polyploids and viable gynogens using spontaneously occurring tetraploid loach, *Misgurnus anguillicaudatus*. *Aquaculture* 117:227-235
6. Basrur VR, Rothfels KH. 1959. Triploidy in natural populations of the black fly *Cnephia mutata* (Malloch). *Canadian Journal of Zoology* 37:571-589
7. Beçak ML, Beçak W. 1974. Diploidization in *Eleutherodactylus* (Leptodactylidae - Amphibia). *Experientia* 30:624-625
8. Bell G. 1982. *The Masterpiece of Nature: The Evolution and Genetics of Sexuality*. Berkeley: University of California Press
9. Bickham JW, Hanks BG, Hale DW, Martin EE. 1993. Ploidy diversity and the production of balanced gametes in male twist-necked turtles *Platemys platycephala*. *Copeia* 3:723-727
10. Block K. 1969. Chromosomal variation in Agromyzidae. II. *Phytomyza cassiseta* Zetterstedt -- A parthenogenetic species. *Hereditas* 62:357-381
11. Bloom SE. 1972. Chromosome abnormalities in chicken (*Gallus domesticus*) embryos: types, frequencies and phenotypic effects. *Chromosoma* 37:309-326
12. Bogart JP. 1980. Evolutionary implications of polyploidy in amphibians and reptiles. In *Polyploidy: Biological Relevance*, ed. WH Lewis, pp. 341-78. New York: Plenum Press
13. Bogart JP, Elinson RP, Licht LE. 1989. Temperature and sperm incorporation in polyploid salamanders. *Science* 246:1032-1034
14. Böök JA. 1940. Triploidy in *Triton taeniatus* Laur. *Hereditas* 26:107-114
15. Bull JJ. 1983. *Evolution of sex determining mechanisms*. Reading, MA: Benjamin/Cummings Pub. Co.
16. Cannatella DC, De Sa RO. 1993. *Xenopus laevis* as a model organism. *Systematic Biology* 42:476-507
17. Chenuil A, Galtier N, Berrebi P. 1999. A test of the hypothesis of an autopolyploid vs. allopolyploid origin for a tetraploid lineage: application to the genus *barbus* (Cyprinidae). *Heredity* 82 Pt 4:373-80
18. Cohen S, Roth LM. 1970. Chromosome numbers in Blattaria. *Ann. Entom. Soc. Amer.* 63:1520-1547
19. Cole CJ. 1983. Specific status of the North American fence lizards, *Sceloporus undulatus* and *Sceloporus occidentalis*, with comments on chromosome variation. *American Museum Novitates* 2768:1-13
20. Collares-Pereira MJ, Madeira JM, Rab P. 1995. Spontaneous triploidy in the stone loach *Noemacheilus barbatulus* (Balitoridae). *Copeia* 2:483-484
21. Darevsky IS, Danielyan FD, Sokolova TM, Rozanov YM. 1989. Intraclonal mating in the parthenogenetic lizard species *Lacerta unisexualis* Darevsky. In *Evolution and Cytology of Unisexual Vertebrates*, ed. RM Dawley, Bogart JP, pp. 228-235. New York: The University of the State of New York
22. Darevsky IS, Kupriyanova LA, Rashchin VV. 1984. A new all-female triploid species of gecko and karyological data on the bisexual *Hemidactylus frenatus* from Vietnam. *J. Herp.* 18:277-284
23. Dawley RM, Schultz RJ, Goddard KA. 1987. Clonal reproduction and polyploidy in unisexual hybrids of *Phoxinus eos* and *Phoxinus neogaeus* (Pisces; Cyprinidae). *Copeia*:275-283
24. Echelle AA, Mosier DT. 1981. All-female fish: A cryptic species of *Menidia* (Atherinidae). *Science* 212:1411-1413
25. Ewing RR, G. SC, P. ED. 1991. Flow Cytometric Identification of Larval Triploid Walleyes. *Progressive Fish Culturist* 53:177-180
26. Feder JH. 1979. Natural hybridization and genetic divergence between the toads *Bufo boreas* and *Bufo punctatus*. *Evolution* 33:1089-1097
27. Formas JR. 1994. A triploid individual of the Chilean leptodactylid frog *Eupsophus vertebralis*. *J. Herp.* 28:394-395

28. Gade B, Parker ED, Jr. 1997. The effect of life cycle stage and genotype on desiccation tolerance in the colonizing parthenogenetic cockroach *Pycnoscelus surinamensis* and its sexual ancestor *P. indicus*. *Journal of Evolutionary Biology* 10:479-493
29. Gallardo MH, Bickham JW, Honeycutt RL, Ojeda RA, Kohler N. 1999. Discovery of tetraploidy in a mammal. *Nature* 401:341
30. Gibson TJ, Spring J. 2000. Evidence in favour of ancient octaploidy in the vertebrate genome. *Biochem. Soc. Trans* 28:259-264
31. Goddard KA, Schultz RJ. 1993. Aclonal reproduction by polyploid members of the clonal hybrid species *Phoxinus eos-neogaeus* (Cyprinidae). *Copeia*:650-660
32. Green D, Delisle D. 1985. Allotriploidy in natural hybrid frogs, *Rana chiricahuensis* x *R. pipiens*, from Arizona: Chromosomes and electrophoretic evidence. *J. Herp.* 19:385-390
33. Green DM, Kezer J, Nussbaum RA. 1984. Triploidy in Hochstetter's frog, *Leiopelma hochstetteri*, from New Zealand. *New Zealand Journal of Zoology* 11:457-460
34. Gui J, Li Y, Li K, Hong Y, Zhou T. 1985. Studies on the karyotypes of Chinese cyprinid fishes. 6. Karyotypes of three tetraploid species in Barbinae and one tetraploid species in Cyprininae. *Acta Genet. Sin.* 12:302-308
35. Haddad CFB, Pombal JP, Jr., Batistic RF. 1994. Natural hybridization between diploid and tetraploid species of leaf-frogs, genus *Phyllomedusa* (Amphibia). *J. Herp.* 28:425-430
36. Hayes TB. 1998. Sex determination and primary sex differentiation in amphibians: Genetic and developmental mechanisms. *Journal of Experimental Zoology* 281:373-399
37. Kasahara S, Haddad CFB. 1997. Karyotypes of two Brazilian microhylid frogs of the genus *Chiasmocleis*, including a new case of polyploidy. *J. Herp.* 31:139-142
38. Kobel HR, Du Pasquier L. 1986. Genetics of polyploid *Xenopus*. *Trends Genet.* 2:310-315
39. Kupriyanova LA. 1989. Cytogenetic evidence for genome interaction in hybrid lacertid lizards. In *Evolution and Cytology of Unisexual Vertebrates*, ed. RM Dawley, Bogart JP, pp. 236-240. New York: The University of the State of New York
40. Kuramoto M, Allison A. 1989. Karyotypes of microhylid frogs of Papua New Guinea and their systematic implications. *Herpetologica* 45:250-259
41. Larhammar D, Risinger C. 1994. Molecular genetic aspects of tetraploidy in the common carp *Cyprinus carpio*. *Molecular Phylogenetics & Evolution* 3:59-68
42. Lokki J, Saura A. 1980. Polyploidy in insect evolution. In *Polyploidy: Biological Relevance*, ed. WH Lewis, pp. 277-312. New York: Plenum Press
43. Lokki J, Suomalainen E, Saura A, Lankinen P. 1975. Genetic polymorphism and evolution in parthenogenetic animals. II. Diploid and polyploid *Solenobia triquetrella* (Lepidoptera: Psychidae). *Genetics* 79:513-25
44. Lowcock LA, Licht LE. 1990. Natural autotriploidy in salamanders. *Genome* 33:674-678
45. Mahony MJ, Robinson ES. 1980. Polyploidy in the Australian leptodactylid frog genus *Neobatrachus*. *Chromosoma* 81:199-212
46. Mazik EJ, T. TA, P. R. 1989. Karyotype Study of Four Species of the Genus *Diptychus* Pisces Cyprinidae With Remarks On Polyploidy of Schizothoracine Fishes. *Folia Zoologica* 38:325-332
47. Mezhzherin SV, M. PE. 1990. Genetic Structure and Origin of Asian Polyploid Toads *Bufo-Danatensis* Pisanetz 1978. *Doklady Akademii Nauk Ukrainskoi Ssr Seriya B Geologicheskije Khimicheskije i Biologicheskije Nauki* 8:71-73
48. Mezhzherin SV, M. PE. 1991. Genetic Divergence in the *Bufo-Viridis* Complex in the Ussr Fauna. *Doklady Akademii Nauk SSSR* 317:222-226
49. Morescalchi A, Olmo E. 1974. Sirenids: a family of polyploid urodeles? *Experientia* 30:491-2
50. Moritz C. 1991. Evolutionary dynamics of mitochondrial DNA duplications in parthenogenetic geckos, *Heteronotia binoei*. *Genetics* 129:221-30
51. Moritz C, Case TJ, Bolger DT, Donnellan S. 1993. Genetic diversity and the history of Pacific island house geckos (*Hemidactylus* and *Lepidodactylus*). *Biological Journal of the Linnean Society* 48:113-133
52. Normark BB. 1996. Polyploidy of parthenogenetic *Aramigus tessellatus* (Say) (Coleoptera: Curculionidae). *Coleopterists Bulletin* 50:73-79
53. Ohno S. 1970. *Evolution by Gene Duplication*. New York: Springer-Verlag

54. Oliveira C, Almeida-Toledo LF, Mori L, Toledo-Filho SA. 1992. Extensive chromosomal rearrangements and nuclear DNA content changes in the evolution of the armoured catfishes genus *Corydoras* (Pisces, Siluriformes, Callichthyidae). *Journal of Fish Biology* 40:4190431
55. Oliveira C, Almeida-Toledo LF, Mori L, Toledo-Filho SA. 1993. Cytogenetic and DNA content in six genera of the family Callichthyidae (Pisces, Siluriformes). *Caryologia* 46:171-188
56. Pandey N, Lakra WS. 1997. Evidence of female heterogamety, B-chromosome and natural tetraploidy in the Asian catfish, *Clarias batrachus*, used in aquaculture. *Aquaculture* 149:1-2
57. Pandian TJ, Koteeswaran R. 1999. Natural occurrence of monoploids and polyploids in the Indian catfish, *Heteropneustes fossilis*. *Curr. Sci.* 76:1134-1137
58. Post A. 1965. Vergleichende Untersuchungen der Chromosomenzahlen bei süßwasser Teleostern. *Ztschr. zool. Syst. u. Evol. - Forsch.* 3:47-93
59. Postlethwait JH, Yan YL, Gates MA, Horne S, Amores A, *et al.* 1998. Vertebrate genome evolution and the zebrafish gene map. *Nature Genet.* 18:345-9
60. Raicu P, Taisescu E. 1972. *Misgurnus fossilis*, a tetraploid fish species. *Journal of Heredity* 63:92-94
61. Ralin DB, Romano MA, Kilpatrick CW. 1983. The tetraploid treefrog *Hyla versicolor*: Evidence for a single origin from the diploid *Hyla chrysoscelis*. *Herpetologica* 39:212-225
62. Rishi KK, Shashikala, Rishi S. 1998. Karyotype study on six Indian hill-stream fishes. *Chromosome Science* 2:9-13
63. Ruiz IRG, Bonaldo MF, Beçak W. 1980. In situ localization of ribosomal genes in a natural triploid of *Odontophrynus*. *Journal of Heredity* 71:55-57
64. Saura A, Lokki J, Lankinen P, Suomalainen E. 1976. Genetic polymorphism and evolution in parthenogenetic animals. III. Tetraploid *Otierrhynchus scaber* (Coleoptera: Curculionidae). *Hereditas* 82:79-99
65. Schmid M, Haaf T, Schemp W. 1985. Chromosome banding in Amphibia. IX. The polyploid karyotypes of *Odontophrynus americanus* and *Ceratophrys ornata* (Anura, Leptodactylidae). *Chromosoma* 91:172-184
66. Schultz RJ. 1980. Role of polyploidy in the evolution of fishes. In *Polyploidy: Biological Relevance*, ed. WH Lewis, pp. 313-40. New York: Plenum Press
67. Shimizu Y, Oshiro T, Sakaizumi M. 1993. Electrophoretic studies of diploid, triploid, and tetraploid forms of the Japanese silver crucian carp, *Carassius auratus langsdorfii*. *Jap. J. Ichth.* 40:65-75
68. Skrabanek L, Wolfe KH. 1998. Eukaryote genome duplication - where's the evidence? *Curr. Opin. Genet. Dev.* 8:694-700
69. Smith SG. 1971. Parthenogenesis and polyploidy in beetles. *American Zoologist* 11:341-349
70. Suzuki A, Taki Y. 1981. Karyotype of tetraploid origin in a tropical Asian cyprinid, *Acrossocheilus sumatranus*. *Jap. J. Ichth.* 28:173-176
71. Tiersch TR, L. BM, M. D. 1991. Zzw Autotriploidy in a Blue-and-Yellow Macaw. *Genetica* 84:209-212
72. Tucic B, Mesaros G. 1992. Chromosome counts in some high altitude *Otierrhynchus* Germ. species from Yugoslavia. *Caryologia* 45:213-219
73. Vasil'yev VP. 1980. Chromosome numbers in fish-like vertebrates and fish. *Journal of Ichthyology* 20:1-38
74. Vervoort A. 1980. Tetraploidy in *Protopterus* (Dipnoi). *Experientia* 36:294-296
75. Vrijenhoek RC, Dawley RM, Cole CJ, Bogart JP. 1989. A list of known unisexual vertebrates. In *Evolution and Cytology of Unisexual Vertebrates*, ed. RM Dawley, Bogart JP, pp. 19-23. New York: The University of the State of New York
76. White MJD. 1973. *Animal Cytology and Evolution*. Cambridge: University of Cambridge Press 3 ed.
77. Wiley JE, Braswell A. 1986. A triploid male of *Rana palustris*. *Copeia* 1986:531-533
78. Wittbrodt J, Meyer A, Schartl M. 1998. More genes in fish? *BioEssays* 20:511-515
79. Witten GJ. 1978. A triploid male individual *Amphibolurus nobbi nobbi* (Witten) (Lacertidae: Agamidae). *Australian Zoologist* 19:305-308
80. Wynn AL, Cole CJ, Gardner AL. 1987. Apparent triploidy in the unisexual Brahminy blind snake, *Ramphotyphlops braminus*. *American Museum Novitates* 2868:1-7
81. Yu X, Zhou T, Li K, Li Y, Zhou M. 1987. On the karyosystematics of cyprinid fishes and a summary of fish chromosome studies in China. *Genetica* 72:225-236