

Analýza pohlavných chromozómov a repetitívne usporiadaných génov u vybraných vtáčkarovitých a araneomorfných pavúkov

Bc. Michaela Pappová

Zoznam použitej literatúry vo forme errat

Araújo, D., Cella, D.M., Brescovit, A.D. (2005): Cytogenetic analysis of the neotropical spider *Nephilengys cruentata* (Araneomorphae, Tetragnathidae): standard staining, NORs, C-bands and base-specific fluorochromes. *Brazilian journal of biology* 65 (2): 193 - 202.

Araújo, D., Schneider, M.C., Paula-Neto, E., Cella, D.M. (2012): Sex chromosomes and meiosis in spiders. *Meiosis - molecular mechanisms and cytogenetic diversity*: 87 – 108.

Araújo, D., Schneider, M.C., Paula-Neto, E., Cella, D.M. (2019): The spider cytogenetic database. Dostupné na: www.arthropodacytogenetics.bio.br/spiderdatabase.

Artoni, R.F. and Bertollo, L.A.C. (2002): Evolutionary aspects of the ZZ/ZW sex chromosome system in the Characidae fish, genus *Tripottheus*. A monophyletic state and NOR location on the W chromosome. *Heredity* 89 (1): 15 – 19.

Benavente, R. and Wettstein, R. (1977). An ultrastructural cytogenetic study on the evolution of sex chromosomes during the spermatogenesis of *Lycosa malitiosa* (Arachnida). *Chromosoma* 64 (3): 255 – 277.

Boisvert, F.M., Koningsbruggen, S., Navascués, J., Lamond, A.I. (2007): The multifunctional nucleolus. *Nature reviews molecular cell biology* 8: 574 – 585.

Bole-Gowda, B.N. (1950): The chromosome study in the spermatogenesis of two lynx-spiders (Oxyopidae). In: *Proceedings of the zoological society of Bengal* 3: 95 - 107.

Bond, J.E., Hendrixson B.E., Hamilton, CH.A., Hedin, M. (2012): A reconsideration of the classification of the spider infraorder Mygalomorphae (Arachnida: Araneae) based on three nuclear genes and morphology. *PloS ONE* 7(6): e38753.

Britton-Davidian, J., Cazaux, B., Catalan, J. (2012): Chromosomal dynamics of nucleolar organizer regions (NORs) in the house mouse: micro-evolutionary insights. *Heredity* 108(1): 68 – 74.

Bueno, D., Palacios-Gimenez, O.M., Cabral-de-Mello, D.C. (2013): Chromosomal mapping of repetitive DNAs in the grasshopper *Abracris flavolineata* reveals possible ancestry of the B chromosome and H3 histone spreading. *PloS ONE* 8 (6): e66532.

- Buchar, J. and Kůrka, A. (1998): Naši pavouci. Vyd.1. – Praha: Academia – 154s. ISBN 80-200-0331-2.
- Cabral-de-Mello, D.C., Oliveira, S.G., Moura, de R.C., Martins, C. (2011): Chromosomal organization of the 18S and 5S rRNAs and histone H3 genes in Scarabaeidae coleopterans: Insights into the evolutionary dynamics of multigene families and heterochromatin. *BMC Genetics* 12: 88.
- Cabral-de-Mello, D.C., Valente, G.T., Nakajima, R.T., Martins, C. (2012): Genomic organization and comparative chromosome mapping of the U1 snRNA gene in cichlid fish, with an emphasis in *Oreochromis niloticus*. *Chromosome research* 20(2): 279 - 292.
- Clark, M.S. & Wall, W.J. (1996): Chromosomes: the complex code. London: Chapman and Hall.
- Coddington, J.A. and Levi, H.W. (1991): Systematics and evolution of spiders (Araneae). *Annual review of ecology and systematics* 22 (1): 565 – 592.
- Conrad, T. and Akhtar, A. (2012): Dosage compensation in *Drosophila melanogaster*: epigenetic fine-tuning of chromosome-wide transcription. *Nature reviews genetics* 13: 123 – 134.
- Dolejš, P., Kořínková, T., Musilová, J., Opatová, V., Kubcová, L., Buchar, J., Král, J. (2011): Karyotypes of central European spiders of the genera *Arctosa*, *Tricca* and *Xerolycosa* (Araneae, Lycosidae). *European journal of entomology* 108(1): 1 - 16.
- Dunlop, J.A. (2019): Miniaturisation in Chelicerata. *Arthropod structure and development* 48: 20 - 34.
- Eickbush, T.H. and Eickbush, D.G. (2007): Finely orchestrated movements: evolution of the ribosomal RNA genes. *Genetics* 175: 477 – 485.
- Engelstädter, J. (2008): Muller's ratchet and the degeneration of Y chromosomes: A simulation study. *Genetics* 180(2): 957 - 967.
- Fedoriw, A.M., Starmer, J., Yee, D., Magnuson, T. (2012): Nucleolar association and transcriptional inhibition through 5S rDNA in mammals. *PLOS Genetics* 8(1): e1002468.
- Foley, S., Lüddecke, T., Cheng, D.Q., Krehenwinkel, H., Künzel, S., Longhorn, J., Wendt, I., Wirth, W., Tänzler, R., Vences, M., Piel, W.H. (2018): Tarantula phylogenomics: A robust phylogeny of multiple tarantula lineages inferred from transcriptome data sheds light on the prickly issue of urticating setae evolution. *BioRxiv*.
- Forman, M., Nguyen, P., Hula, V., Král, J. (2013): Sex chromosome pairing and extensive NOR polymorphism in *Wadicosa fidelis* (Araneae: Lycosidae). *Cytogenetic genome research* 141: 43 - 49.

- Gamble, T. and Zarkower, D. (2012): Sex determination. *Science direct* 22(8): 257 - 262.
- Gerbi, S.A., Borovjagin, A.V., Odreman, F.E., Lange, T.S. (2003): U4 snRNA nucleolar localization requires the NHPX/15.5-kD protein binding site but not Sm protein or U6 snRNA association. *Journal of cell biology* 162(5): 821 - 832.
- Graves, J. (2006): Sex chromosome specialization and degeneration in mammals. *Cell* 124: 901 – 914.
- Gruetzner, F., Ashley, T., Rowell, D.M., Graves, J.A.M. (2006): How did the *Platypus* get its sex chromosome chain? A comparison of meiotic multiples and sex chromosomes in plants and animals. *Chromosoma* 115(2): 75 - 88.
- Hackman, W. (1948). Chromosomenstudien an Araneen mit besonderer Berücksichtigung der Geschlechtschromosomen. *Acta zoologica fennica*. 54: 1–101.
- Hallacli, E. and Akhtar, A. (2009): X chromosomal regulation in flies: when less is more. *Chromosome research* 17: 603 – 619.
- Hendrixson, B.E. and Bond, J.E. (2007): Testing species boundaries in the *Antrodiaetus unicolor* complex (Araneae: Mygalomorphae: Antrodiaetidae): “Paraphyly” and cryptic diversity. *Molecular phylogenetics and evolution* 36: 405 – 416.
- Henras, A.K., Plisson-Chastang, C., O’Donohue, M.F., Chakraborty, A., Gleizes, E. (2014): An overview of pre-ribosomal RNA processing in eukaryotes. *Wiley online library* 6(2): 225 - 242.
- Hernandez - Verdun, D. (2011): Assembly and disassembly of nucleolus during the cell cycle. *Nucleus* 2(3): 189 - 194.
- Hrubá, B. (2017): Analýza karyotypu u sklípkanů čeledí Hexathelidae a Dipluridae, Diplomová práce, Přírodovědecká fakulta Univerzity Karlovy, Praha
- Chandrasekera, A., Jayarathne, V., Fonseka, D. (2017): Molecular methods developed for the identification and characterization of *Candida* species. *International journal of open access ophthalmology* 4(1): 6.
- Charlesworth, B. (1978): Model for evolution of Y chromosomes and dosage compensation. *Proceedings of the national academy of sciences* 75(11): 5618 - 5622.
- Charlesworth, B. (1996): The evolution of chromosomal sex determination and dosage compensation. *Science direct* 6(2): 149 - 162.

- Charlesworth, D., Charlesworth, B., Marais, G. (2005): Steps in the evolution of heteromorphic sex chromosomes. *Heredity* 95(2): 118 - 128.
- Jetybayev, I. Y., Bugrov, A. G., Buleu, O. G., Bogomolov, A. B., Rubtsov, N. B. (2017): Origin and evolution of the neo-sex chromosomes in Pamphagidae grasshoppers through chromosome fusion and following heteromorphization. *Genes* 8(11): 323.
- Jordan, W., Rieder, L.E., Larschan, E. (2019): Diverse genome topologies characterize dosage compensation across species. *Science direct* 35(4): 308 - 315.
- Kambas, D. (2019): Tarantupedia: an online taxonomic database for the world's largest spiders. Dostupné na: www.tarantupedia.com.
- Kovařík, F. (2006): Svět sklípkanů. Madagaskar - 227 s. ISBN: 8086068404
- Kořínková, T. & Král, J. (2013): Karyotypes, sex chromosomes, and meiotic division in spiders. Spider ecophysiology. *Springer Berlin Heidelberg*: 159 – 171.
- Král, J. (2007): Evolution of multiple sex chromosomes in the spider genus *Malthonica* (Araneae, Agelenidae) indicates unique structure of the spider sex chromosome systems. *Chromosome research* 15: 863 - 879.
- Král, J., Kořínková, T., Forman, M., Krkavcová, L. (2011): Insights into the meiotic behavior and evolution of multiple sex chromosome systems in spiders. *Cytogenetic and genome research* 133 (1): 43 - 66.
- Král, J., Kořínková, T., Krkavcová, L., Musilová, J., Forman, M., Herrera, I.M.Á., Hedin, M. (2013): Evolution of karyotype, sex chromosomes, and meiosis in mygalomorph spiders (Araneae: Mygalomorphae). *Biological journal of the Linnean society* 109(2): 377 - 408.
- Král, J., Musilová, J., Štáhlavský, F., Řezáč, M., Akan, Z., Edwards, R.L., Coyle, F.A., Ribera Almerje, C. (2006): Evolution of the karyotype and sex chromosome systems in basal clades of araneomorph spiders (Araneae: Araneomorphae). *Chromosome research* 14: 859 - 880.
- Lifton, R.P., Goldberg, M.L., Karp, R.W., Hogness, D.S. (1978): The organization of the histone genes in *Drosophila melanogaster*: Functional and evolutionary implications. *Cold spring harbor symposia on quantitative biology* 42: 1047 - 1051.

- Lüddecke, T., Krehenwinkel, H., Canning, G., Glaw, F., Longhorn S.J., Tänzler, R., Wendt, I., Vences, M. (2017): Discovering the silk road: nuclear and mitochondrial sequence data resolve the phylogenetic relationships among theraphosid spider subfamilies. *Molecular phylogenetics and evolution* 119: 63 – 70.
- Lyon, M.F. (1974): Evolution of X-chromosome inactivation in mammals. *Nature* 250 (5468): 651 - 653.
- Macas, J., Novák, P., Pellicer, J., Čížková, J., Koblížková, A., Neumann, P., Fuková, I., Doležel, J., Kelly, L.J., Leitch, I.J. (2015): In depth characterization of repetitive DNA in 23 plant genomes reveals sources of genome size variation in the legume *Tribe Fabaeae*. *PLoS ONE* 10(11): e0143424.
- Maddison, W.P. (1982): XXXY sex chromosomes in males of the jumping spider genus *Pellenes* (Araneae: Salticidae). *Chromosoma* 85(1): 23 - 37.
- Maddison, W.P. and Leduc-Robert, G. (2013): Multiple origins of sex chromosome fusions correlated with chiasma localization in *Habronattus* jumping spiders (Araneae: Salticidae). *Evolution* 67(8): 2258 - 2272.
- Martins, C. and Galetti P.M. (2001): Two 5S rDNA arrays in neotropical fish species: is it a general rule for fishes? *Genetica* 111: 439 – 446.
- Martins, C., Wasko, A.P. (2004): Organization and evolution of 5S ribosomal DNA in the fish genome. In: *Williams CR: Focus on genome research. Nova science publishers*: 335 – 363.
- Marz, M., Kirsten, T., Stadler, P.F. (2008): Evolution of spliceosomal snRNA genes in metazoan animals. *Journal of molecular evolution* 67 (6): 594 – 607.
- Matsubara, K., Tarui, H., Toriba, M., Yamada, K., Nishida Umehara, C., Agata, K., Matsuda, Y. (2006): Evidence for different origin of sex chromosomes in snakes, birds, and mammals and step-wise differentiation of snake sex chromosomes. *Proceedings of the national academy of sciences* 103:18190 – 18195.
- Maxson, R., Cohn, R., Kedes, L. (1983): Expression and organization of histone genes. *Annual review genetics* 17: 239 - 77.
- McStay, B. (2016): Nucleolar organizer regions: genomic ‘dark matter’ requiring illumination. *Genes and development* 30: 1598 – 1610.
- Muller, H. J. (1964): The relation of recombination to mutational advance. *Mutation research - fundamental and molecular mechanisms of mutagenesis* 1(1): 2 - 9.

- Németh, A., & Grummt, I. (2018): Dynamic regulation of nucleolar architecture. *Current opinion in cell biology* 52: 105 - 111.
- Novotná, J., Havelka, J., Starý, P., Koutecký, P., Vítková, M. (2011): Karyotype analysis of the Russian wheat aphid, *Diuraphis noxia* (Kurdjumov) (Hemiptera: Aphididae) reveals a large X chromosome with rRNA and histone gene families. *Genetica* 139(3): 281 - 289.
- Ohno, S. (1967): Chromosomes and sex-linked genes. New York: Springer. 192. ISBN 978-3-642-88178-7.
- Old, R.W., Callan, G.H., Gross, K.W. (1977): Localization of histone gene transcripts in newt lampbrush chromosomes by in-situ hybridization. *Journal of cell science* 27: 57 – 79.
- Pätau, K. (1948): X - segregation and heterochromasy in the spider *Aranea reaumuri*. *Heredity* 2: 77 – 100.
- Pajpach, F. (2018): Karyotypová evoluce pavouků čeledi Araneidae, Diplomová práce, Přírodovědecká fakulta Univerzity Karlovy, Praha.
- Palacios-Gimenez, O.M., Cabral-de-Mello, D.C. (2015): Repetitive DNA chromosomal organization in the cricket *Cycloptiloides americanus*: a case of the unusual X₁X₂0 sex chromosome system in Orthoptera. *Molecular genetics and genomics* 290 (2): 623 – 631.
- Pederson, T. (2011): The nucleolus. *Cold spring harbor perspectives in biology* 3, 102 (14): 5084 - 5089.
- Postiglioni, A. & Brum- Zorrilla, N. (1981): Karyological studies on Uruguayan spiders II. Sex chromosomes in spiders of the genus *Lycosa* (Araneae - Lycosidae). *Genetica* 56(1): 47 - 53.
- Prokopcová, L. (2018): Analýza karyotypu u mesothelidních pavúků, Diplomová práce, Přírodovědecká fakulta Univerzity Karlovy, Praha.
- Ranz, J.M., González, J., Casals, F., Ruiz, A. (2003): Low occurrence of gene transposition events during the evolution of the genus *Drosophila*. *Evolution* 57: 1325 – 1335.
- Raska, I., Shaw, P.J., Cmarko, D. (2006): Structure and function of the nucleolus in the spotlight. *Current opinion in cell biology* 18: 325 – 334.
- Rice, W. R. (1996): Evolution of the Y sex chromosome in animals. *Bioscience* 46: 331 - 343.

- Rooney, A.P., Ward, T.J. (2005): Evolution of a large ribosomal RNA multigene family in filamentous fungi: birth and death of a concerted evolution paradigm. *Proceedings of the national academy of sciences of the United States of America* 102 (14): 5084 – 5089.
- Řezáč, M., Král, J., Musilová, J., Pekár, S. (2006): Unusual karyotype diversity in the European spiders of the genus *Atypus* (Araneae: Atypidae). *Hereditas* 143: 123 – 129.
- Sadílek, D., Nguyen, P., Koç, H., Kovařík, F., Yağmur, E.A., Šťáhlavský, F. (2015): Molecular cytogenetics of *Androctonus* scorpions: an oasis of calm in the turbulent karyotype evolution of the diverse family Buthidae. *Biological journal of the linnean society* 115 (1): 69 – 76.
- Selden, P.A. and Gall, J.C. (1992): A Triassic mygalomorph spider from the northern Vosges, France. *Palaeontology* 35: 211 - 235.
- Silva, D.M., Utsunomia, R., Pansonato-Alves, J.C., Oliveira, C., Foresti, F. (2015): Chromosomal mapping of repetitive DNA sequences in five species of *Astyanax* (Characiformes, Characidae) reveals independent location of U1 and U2 snRNA sites and association of U1 snRNA and 5S rDNA. *Cytogenet genome research* 146(2): 144 - 52.
- Simon, L., Rabanal, F.A., Dubos, T., Oliver, C., Lauber, D., Poulet, A., Vogt, A., Mandlbauer, A., Le Goff, S., Sommer, A., Duborjal, H., Tatout, Ch., Probst, A.V. (2018): Genetic and epigenetic variation in 5S ribosomal RNA genes reveals genome dynamics in *Arabidopsis thaliana*. *Nucleic acids research*: 46 (6): 3019 – 3033.
- Simpson, R.T. (1978): Structure of chromatosome, a chromatin particle containing 160 base pairs of DNA and all the histones. *Biochemistry* 17, 25: 5524 - 5531.
- Sochorová, J., Garcia, S., Gálvez, F., Symonová, R., Kovařík, A. (2017): Evolutionary trends in animal ribosomal DNA loci: introduction to a newonline database. *Chromosoma* 127 (1): 141 – 150.
- Stults, D.M., Killen, M.W., Williamson, E.P., Hourigan, J.S., Vargas, H.D., Arnold, S.M., Moscow, J.A., Pierce, A.J. (2009): Human rRNA gene clusters are recombinational hotspots in cancer. *Cancer research* 69: 9096 – 9104.
- Sumner, A.T. (2003). Chromosomes - Organization and Function. 1st ed. Malden. Oxford, Melbourne, Berlin: Blackwell Publishing Company – 294. ISBN 13: 9780632054077.
- Suzuki, G., Kubota, S. (2011): 5S ribosomal DNA cluster of a lynx spider *Oxyopes sertatus* includes a histone H2Blike gene in the spacer region (NTS). *Chromosome science* 14: 3 - 8.

- Suzuki, S. (1954): Cytogenetical studies in spiders. III. Studies on the chromosomes of fifty-seven species of spiders belonging to seventeen families, with general considerations on chromosomal evolution. *Journal of science of the Hiroshima university Series B*, 15: 23-136.
- Swan, A. (2012): Meiosis: Molecular mechanisms and cytogenetic diversity. Intech Open. ISBN 978-953-51-0118-5.
- Svojanovská, H., Nguyen, P., Hiřman, M., Tuf, I.H., Wahab, R.A., Haddad, C.R., Šťáhlavský, F. (2016): Karyotype evolution in harvestmen of the suborder Cyphophthalmi (Opiliones). *Cytogenetic and genome research* 148(2-3): 227 - 36.
- Szymanski, M., Barciszewska, M.Z., Erdmann, V.A., Barciszewska, J. (2002): 5S Ribosomal RNA Database. *Nucleic acids research* 30(1): 176–178.
- Šichová, J., Voleníková, A., Dincă, V., Nguyen, P., Vila, R., Sahara, K., Marec, F. (2015): Dynamic karyotype evolution and unique sex determination systems in *Leptidea* wood white butterflies. *BMC evolutionary biology*: 89.
- Tarn, W.Y. and Steitz, J.A. (1997): Pre-mRNA splicing: the discovery of a new spliceosome doubles the challenge. *Trends in biochemical sciences* 22: 132 – 137.
- Turowski, T.W. and Tollervey, D. (2015): Cotranscriptional events in eukaryotic ribosome synthesis. *Wiley interdisciplinary review RNA* 6: 129 – 139.
- Uberla, K., Platzer, C., Diamantstein, T., Blankenstein, T. (1991): Generation of competitor DNA fragments for quantitative PCR. *Genome research* 1: 136 - 139.
- Vierna, J., Jensen, K.T., Martinez-Lage, A., Gonzalez-Tizon, A.M. (2012): The linked units of 5S rDNA and U1 snDNA of razor shells (Mollusca: Bivalvia: Pharidae). *Heredity* 107:127 –142.
- Warner, J.R. (1979): Distribution of newly formed ribosomal proteins in Hela cell fractions. *Cell biology* 80: 767 - 772.
- Warner, W.A., Spencer, D., Trissal, M., Helton, N., Ley, T.J., Link D.C. (2015): Characterization of snoRNA expression in acute myeloid leukemia blood. *American society of hematology* 126: 3649.
- Wheeler, W.C., Coddington, J.A., Crowley L.M., Dimitrov, D., Goloboff, P.A., Griswold, C.E., Hormiga, G., Prendini, L., Ramírez, M.J., Sierwald, P., Almeida-Silva, L., Alvarez-Padilla, F., Arnedo, M.A., Benavides Silva, L.R., Benjamin, S.P., Bond, J.E., Grismado, C.J., Hasan, E., Hedin, M., et al. (2016): The spider tree of life: Phylogeny of Araneae based on target-gene analyses from an extensive taxon sampling. *Cladistics*: 1 – 43.

- White, M.J.D. (1973): Animal cytology and evolution. 3rd ed. London: Cambridge University Press.
ISBN 13: 9780521070713
- World Spider Catalog (2019). World Spider Catalog. Version 20.5. Natural History Museum Bern.
Dostupné na: <http://wsc.nmbe.ch>.
- Xu, X., Liu, F., Chen, J., Ono, H., Agnarsson, I., Li, D., Kuntner, M. (2016): Pre- pleistocene geological events shaping diversification and distribution of primitively segmented spiders on east Asia margins. *Journal of biogeography* 43: 1004 - 1019.
- Xu, X., Liu, F., Chang, R.CH., Chen, J., Xu, X., Zhang, Z., Ono, H., Pham, D.S., Norma- Rashid, Y., Arnedo, M.A., Kuntner, M., Li, D. (2015): Extant primitively segmented spiders have recently diversified from an ancient lineage. *Proceedings of the royal society of London B: Biological sciences* 282(1808): 20142486.
- Yoshikawa H., Ishikawa H., Izumikawa K., Miura, Y., Hayano T., Isobe T., Simpson R.J., Takahashi N. (2015): Human nucleolar protein Nop52 (RRP1/NNP-1) is involved in site 2 cleavage in internal transcribed spacer1 of pre-rRNAs at early stages of ribosome biogenesis. *Nucleic acids research* 43: 5524 – 5536.
- Zefa, E., Redü, D.R., Costa, M.K.M., Fontanetti, C.S., Gottschalk, M.S., Padilha, G.B., Silva, A.S., Martins, L.P. (2014): A new species of *Endecous* Saussure, 1878 (Orthoptera, Gryllidae) from northeast Brazil with the first X₁X₂0 chromosomal sex system in Gryllidae. *Zootaxa* 3847(1):125 - 132.