Paleocene-Eocene freshwater aquatic and wetland ecosystems of the Zeya-Bureya Basin, Russian Far East and their responses to climate change

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The Paleocene middle and upper members of the Tsagayan Formation with uppermost Kivda beds and the Eocene Raichikha Formation in the SE part of the Zeya-Bureya Basin (Amur Region, Russian Far East) have yielded rich fossil records of plants (megafossils and palynomorphs), insects, and invertebrates (Krassilov, 1976; Kamaeva, 1990; Flora and dinosaurs…, 2001; Akhmetiev et al. 2002). The Lower Tertiary coal-bearing sediments were deposited on a broad alluvial plain. Freshwater wetlands were widely distributed across the region. Several types of paleoenvironments with associated floristic and faunal assemblages have been recognized: flood plains, shallow lakes and ponds, peatswamps, and streembanks with levees. Because freshwater aquatic and wetland ecosystems are very vulnerable to climate change, their study can provide additional data useful for our understanding of terrestrial biota responses to global climatic event at the Paleocene/Eocene boundary.

The Paleocene Middle Tsagayan wetlands were dominated by plant communities including mainly *Taxodium – Nyssa – Mesocyparis* swamp forests. Herbaceous plants (horsetail *Equisetum,* ferns *Osmunda* and *Woodwardia,* monocot *Zingiberopsis*) could have inhabited freshwater marshes. The Tsagayan aquatic plants are relatively diverse and represent primarily extinct genera *Nelumbites, Nuphar, Quereuxia, Haemanthophyllum, Paranymphaea*. The only free-floating plant is *Quereuxia.* Shallow lake sediments represented by gray indistinctly laminated clays contain rare freshwater gastropod remains (cf. *Viviparus*) and numerous aquatic and terrestrial fossil insects. The Tsagayan insect assemblages are dominated by dragonflies (Odonata, mainly suborder Zygoptera), cockroaches (Blattodea), cicadas and bugs (Homoptera, Heteroptera), beetles (Coleoptera, families Gyrinidae, Buprestidae and Cupedidae), and caddisflies (Trichoptera), while mayflies **(**Ephemeroptera), scorpionflies (Mecoptera**),** and Phasmatodea insects are less abundant (Popov, 1971; Ponomarenko, 1977, Sukatsheva, 1982; Alexeev, 1995; Vasilenko, Bugdaeva, 2006). The evidences of plant-insect interactions (leaf damages, galls, mines) have also been recorded.

The Kivda wetlands were inhabited by *Taxodium, Metasequoia, Ditaxocladus, Pseudolarix,* and *Myrica.* The most common plants of non-forested wetlands in the region were horsetails (*Equisetum*)*,* ferns (e.g. *Arctopteris*) and especially monocots including aroid plant *Caladiosoma*. The only two aquatic plants are known: unidentified free-floating plant of the Hydrocharitaceae family and fern *Azolla*. Abundant *Daphnia* in sediments indicates eutrophic water. Generally, lowland deciduous coniferous-broadleaved forests with Taxodiaceae, *Trochodendroides*, platanoids, Betulaceae, and cornalean plants are reconstructed for the Tsagayan time. The climate was humid warm-temperate to temperate.

The Eocene Raichikha flora is highly distinct from those of Paleocene. None of the woody angiosperm Raichikha taxa are known from Tsagayan flora. Raichikha plant assemblage is dominated by Lauraceae, Leguminosae, Rhamnaceae, Sapindaceae (Akhmetiev, 1973, 2008; Fedotov, 1983). Physiognomic analysis of fossil leaves indicates a MAT of 14.8 - 15°C. The thermophilic character of the Eocene flora of the Zeya-Bureya Basin may be explained by relatively rapid plant migrations during global warming at the Paleocene/Eocene boundary. Possible migration routs are discussed. The Raichikha aquatic ecosystems have changed considerably. Aquatic and helophytic plant communities has yielded both dicots (*Nelumbo, Nuphar*) and monocots (*Limnobiophyllum*, Araceae), as well as heterosporous ferns (*Salvinia, Azolla, Regnellidium*). Insect assemblages are dominated by mayflies **(**Ephemeroptera). The wetlands were inhabited mainly by shrubs (*Hibiscus, Myrica, Vaccinium*) and ferns. Some aquatic plants demonstrate high level of adaptability to the environment variations.