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Progress of the Forest DIWPA-IBOY Program in North-West Part of the Pan-Japan Sea Area

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Introduction

The problem of biodiversity of the World and its regions is widely discussed now. Insects are much more abundant than other living organisms together. Excellent arguments have been made for 5-15 million (Stork, 1997), 12.5 million (Hammond, 1992), but estimated number even may be up to 30 millions extant insect species (Erwin, 1982).

The International Network for DIVERSITAS in the Western Pacific and Asia (DIWPA) was established in 1993 with a series of biodiversity focussed goals including the inventory and monitoring of biodiversity and ecosystem function of biodiversity. DIWPA has led to much improved collaboration between biodiversity researches and has organized in 2001 the "International Biodiversity Observation Year" (IBOY). The forest IBOY program was focus on the biodiversity of the sites in the region from Russia to Australia.

The main aim of this paper is to discuss the first results of the IBOY activity in the core site at Ussuriiskii Reserve as well as in the satellite sites at Muraveva-Amskii Peninsula in the Russian part of the Pan-Japan Sea Area. A special attempt is made in comparison of the insect diversity of the studied plot with the biodiversity of the Primorski krai and Russian Far East.

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Insect diversity of the Russian Far East

Russian Far East occupies the square 3016 thousand sq. km. and extends from Wrangel II. (71° N) southwards to Khasan Lake (42° N) and from Dezhneve Cape (170° W) westwards to Stanovoj Range (120° E). The forests occupy 39% of this square and dominate in Primorski krai, Khabarovskii krai, Amurskaya oblast, and Sakhalin II. The insect fauna of Russian Far East is represented by about 31500 estimated species from 629 recorded families of 31 orders (Storozenko et al., 2002). The largest orders are Hymenoptera (72 families, 9000 estimated species), Diptera (119 families, 8000 species), Coleoptera (114 families, 5500 species), Lepidoptera (81 families, 5000 species). The most insect orders are well represented in each region except Chukotka.

There are four levels of insect family diversity: around 200 families (Chukotka), around 300 (Magadanskaya oblast and Kamchatskaya oblast), around 450 (Amurskaya oblast, southern part of Khabarovskii krai, Sakhalin and Kuril Islands), and 600 families (Primorski krai). Insects are best and well represented at the species level in Primorski krai, mostly in its extremal southern part (about 22600 estimated species).

Three regions in Holarctic have almost the same number of species: Russian Far East (Storozenko et al., 2002), Japan (Hirashima, 1990) and Canada (Danks et al., 1997). Russian Far East and Canada belong to temperate zone of Holarctic. Southern borders of these vast regions have the same latitude (42°N), which result in similarity of climatic and vegetation belts. These factors have strong influence for distribution and diversity of insects. Therefore total number of insect species in both regions is almost equal, and percentages of Lepidoptera (16% of total species) and Diptera (24-25%) are the same, but the beetles are more numerous in Canada. The number of recorded insect spe-
cies for Japan in spite of it rather small square is approximately the same as for Russian Far East and Canada. The reason of such similarity depends on more southern position of Japan (up to 23° N). Coleoptera represented in Japanese fauna much better (32% of total insect species) than in Canada (25%) or Russian Far East (17%), probably it results of the increasing of beetle percentage for subtropical faunas.

The core site in the Russian Far East
The core site in Russia has been established in Primorskiy krai near Ussuriskii Natural Reserve. A one hectare plot have been selected in the vicinity of Kamenshchik village on the top of the hill (200m above sea level) on left side of Volga River (43°36.63′N, 132°14.18′E) in mixed coniferous-broad-leaved forest. A plot was established according DIWPA-IBoy recommendations (Toda, Kitching, 1999).

The plant diversity of the mixed coniferous-broad-leaved forest at plot is characterized by follow (Storozhenko, 2003). There are 91 recorded species of vascular plants: trees, bushes and lianas are represent by 34 species, the herbs by 57 species. The number of herb species at plot will be increased after studying of ephemeral spring herbs and sedges (Carex). The three layers at plot consist of 3 sub-layers: highest (at a height of 23-27m, with Abies holophylla, Pinus koraiensis, Quercus mongolica, Tilia amurensis, Betula platyphylha and other trees with mean diameter about 40-60cm), median (at a height of 16-20m, the same species plus Acer mono with mean diameter about 20-25cm), and lower (at a height of 8-12m, composing by Acer pseudosieboldianum, Carpinus cordata and young trees with mean diameter about 10-12cm). The shrub layer is mosaic and composing by 14 plant species. Corylus mandshurica is dominant here. The herb layer (about 60 species) at plot is not uniform. The forbs and graminoids are dominant in the half of plot, in other half the cryptogams are most abundant.

Results of arthropod collecting in the core site
To collect arthropods in canopy and ground zones of plot the follow seven techniques and traps recommend by DIWPA-IBoy [9] are used: light traps, Malaise traps, window traps, pitfall traps, banana traps, litter sampling, and bark spraying. All types of traps were concurrently used periodically from 25 June to 12 September 2001. After collecting and fixation of the entomological materials all samples have been sorted to ordinal or families levels. A part of arthropods is fixed in alcohol (mainly from window traps, pitfall traps, banana traps, bark spraying, and litter sampling), the specimens from light traps and Malaise traps are kept mainly in cotton layers in dry condition. All data are stored in database using Excel. The 33619 specimens of arthropods from 118 samples in plot have been collected totally. The most abundant orders are Diptera (17479 specimens) and Lepidoptera (8888 specimens). The orders Coleoptera (2128 specimens), Hymenoptera (1332 specimens), Collembola (746 specimen), Homoptera (686 specimens) and Acari (1077 specimens) are well represented too. Other insect orders and arthropod groups are represented by about 1300 specimens.

A. Light traps. The standard Pennsylvania trap with 8W daylight fluorescent tube and 12v battery is used. We operate 2 traps, one at ground level and one in the canopy. The 20 samples are made at randomly determined points (10 at ground level and 10 at canopy). The 19598 specimens of insects and other arthropod have been collected totally. The orders Lepidoptera, Coleoptera and Hymenoptera are represent in canopy zone slightly better than in ground. On the contrary the number of specimens of Diptera, Homoptera and Heteroptera in the ground zone are about twice greater than in canopy.

B. Malaise traps. We use two standard Malaise traps. The 25 samples (13 at ground level and 12 at canopy) are made. The 10039 arthropod specimens have been collected. All large orders (Diptera, Hymenoptera, Lepidoptera, Coleoptera, Homoptera) are represent in ground zone considerably (2-10 times) better than in canopy.

C. Window traps. We operate two window traps. The 501 specimens of insects and other arthropod have been collected from 18 samples (9 at ground level and 9 at canopy). The orders Diptera, Hymenoptera and Collembola are represent in ground zone 2-3 times better than in canopy. On the contrary the number of specimens of Homoptera and Coleoptera in canopy zone are about twice greater than in ground.

D. Pitfall traps. We use 60mm plastic tubes with detergent as a killing agent. Five traps are arranged in a cross with 0.5 meter between each trap as a trapping "unit". Totally 1842 specimens of insects and other arthropods were collected from 17 "units". The Collembolla, Diptera, Hymenoptera and Coleoptera are most abundant.

E. Banana traps. Twenty-four samples have been made using banana traps (6 samples at ground, 6 - at 1.3m, 6 - at 2.5m and 6 - at 6m above ground level). Drosophilidae (Diptera) is dominate here (144 specimens).
F. Litter sampling. We collect 2 samples from random points in the plot. Each comprises about a litre of moist leaf scraped up from around the selected point. The Acari, Diptera, and Collembola are most abundant here.

G. Bark spraying. The bark spraying was made on square unit (1x0.5m) of 5 tree species: oak (Quercus mongolica), birch (Betula platyphylla), ashwood (Fraxinus mandshurica), fir (Abies holophylla), pine (Pinus koraiensis), and in hollow of old oak tree. The arthropod fauna of the bark surface of trees quite different from fauna of hollow, mainly by increasing of the Diptera family Phoridae, and order Orthoptera in hollow. The number of specimens of different orders on bark surface is similar for all tree species, except Collembola and Acari, which are more numerous on the Fraxinus mandshurica bark.

Preliminary analysis of insect diversity of the core site

For a few groups of insects, such as orders Coleoptera, Orthoptera, Ephemeroptera, Trichoptera, and families Drosophilidae (Diptera) and Formicidae (Hymenoptera) all collected in the core site specimens were determine up to species (Storozhenko et al., 2003; Thiunova, Storozhenko, 2003; Arefina, Storozhenko, 2003; Kholin, Kupianskaya, 2003). It give possibility to compare the biodiversity in plot (0.01 sq. km) with diversity of local (Ussuriiskii Reserve, 405 sq. km) and regional (Primorski krai, 169900 sq. km) faunas (Storozhenko, 2003).

The fauna of Primorski krai consists of 117 families of Diptera, but only 39 families (33.3%) are mentioned from the plot. There are three large groups of the families in the plot: most abundant families (more than 100 collected specimens), common families (10-100 specimens totally), and rare families (less than 10 specimens). Beside must abundant Diptera the families Muscidae, Tabanidae and Scarid flies are dominant in Malaise traps, Ceratopigidae, Tipulidae and Sclerid flies very common in light traps, and Drosophilidae were collected mainly in banana and light traps. Seventeen families of Diptera are common, the majority of them well represent in Malaise and light traps. The Sphaeroceridae and Antomiidae were collected mainly in pitfall traps. Empididae are dominant in window traps. Eleven families of Diptera are rare and represented by 1-5 specimens in all types of traps totally.

In Primorski krai the number of the species of family Drosophilidae (Diptera) and order Orthoptera are almost the same (114 and 102 species respectively). But the fauna of plot is quite different in both groups. Drosophilidae are well represent in studied forest ecosystem (58% of local fauna of Ussuriiskii Reserve, and 39% of regional fauna of Primorski krai), while Orthoptera occupied mainly open areas and are pure represent in plot (8% and 4% respectively).

Eleven species of ants (Hymenoptera: Formicidae) were collected in plot, which consist 18% of the fauna of Primorski krai, and 39% of Ussuriiskii Reserve respectively (Kholin, Kupianskaya, 2003).

The fauna of Coleoptera of Primorski krai is represented by 3800 species from 104 families. Only 212 species from 51 families were collected by all types of traps in plot, which consist 49% of families and 5.6% species of the fauna of Primorski krai (Storozhenko et al., 2003). The most diverse families in plot are Staphylinidae (38 species from 22 genera), Carabidae (28 species from 16 genera) and Nitidulidae (17 species from 10 genera), each other family is represent by 1-8 species.

The fauna of Caddisflies (Trichoptera) of Primorski krai is represented by 254 species from 92 genera and 25 families. The fauna of Ussuriiskii Reserve consists of 78 species from 43 genera and 20 families. Only 22 species from 16 genera and 11 families were collected in plot at Kamenshuka by light traps in the canopy and ground zones, which consist 44% of families, 17.4% genera and 8.7% species of the fauna of Primorski krai, and 55%, 37.2% and 28.2% of Ussuriiskii Reserve respectively. The number of specimens of Trichoptera in the canopy and ground zones in plot is almost the same, but number of species is quite differing: 20 species occurred in ground zone, and only 11 ones in canopy zone (Arefina, Storozhenko, 2003).

The fauna of Mayflies (Ephemeroptera) of Primorski krai is represented by 91 species from 11 families. Only 4 species from 3 families were collected by Light traps in the canopy and ground zones in plot at Kamenshuka, which consist 27.3% of families and 4.4% species of the fauna of Primorski krai (Thiunova, Storozhenko, 2003).

In orders Coleoptera, Orthoptera, Ephemeroptera, Trichoptera, as well as families Drosophilidae and Formicidae all collected in plot specimens belong to known species. New species will be found beside insects poorly
studied in Russian Far East. For example, two new genera and 33 new species of gall midges (Diptera, Cecidomyiidae) have been described based on material collected in plot (Fedotova, 2002, 2003; Fedotova, Sidorenko, 2003).

**Satellite sites at vicinities of Vladivostok**

After meeting in Kanazawa in March 2003 the Japanese and Russian entomologist outline a plan to study the insect diversity of forest ecosystems in respect to human activity and pollution in the Pan-Japan Sea Area using DIWPA-IHOY data. A newly started project, the 21st-Century COE program aims to elucidate the effects of human-generated environmental changes on biodiversity and ecosystem functions in the Pan-Japan Sea Area and thus, can be regarded as being the next stage of DIWPA-IHOY that has worked with such basic information as the actual status and spatial and temporal trends of biodiversity in natural ecosystems within Western Pacific and Asian region (Tanabe et al., 2003).

Seven satellite sites was selected in Russia at vicinities of Vladivostok (Murav‘eva-Amurskii Peninsula) in 2003:

1. Secondary broad-leaved forest (Nagornii Park) inside Vladivostok;
2. Oak forest at lower slopes of mountain near the highway;
3. Oak forest at the top of the mountain;
4. Primary mixed coniferous-broad-leaved forest at the middle slopes of mountain;
5. Primary mixed coniferous-broad-leaved forest at the lower slopes of mountain;
6. Secondary broad-leaved forest in valley of Bogataya River;
7. Grassland nears the pond in valley of Bogataya River.

The sampling was made using pitfall traps only on 14 June, 1 August, 4 September and 15 October 2003. Totally 7427 specimens of arthropods were collected. All specimens have been sorted to ordinal or families levels according DIWPA-IHOY recommendations. Almost all arthropods are fixed in alcohol, but the beetles (Coleoptera) are pinned, labelled and kept in dry condition. The data obtained by pitfall traps in 2003 (sites No 1-7) and in 2001 (core site, No 8) are given in Table 1.

The ground beetles (Coleoptera: Carabidae) was selected as a primary model group. The specimens of the ground beetles from all sites have been determinate to species. In comparison with data obtained in 2001 for core site at Kamenshika by pitfall traps only, the diversity of Carabidae in satellite sites looks as follow: 1) Nagornii park (74 specimens, 18 species), 2) oak forest near the highway (68 specimens, 9 species), 3) oak forest at the top of the mountain (22 specimens, 4 species), 4) mixed coniferous-broad-leaved forest at the middle slopes (100 specimens, 10 species), 5)

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mixed coniferous-broad-leaved forest at the lower slopes (75 specimens, 10 species), 6) broad-leaved forest in valley (189 specimens, 19 species), 7) grassland near the pond (112 specimens, 21 species), 8) mixed coniferous-broad-leaved forest at Kamenushka (105 specimens, 9 species). Totally 59 species from 19 genera were collected in all sites.

Faunal similarities between sites were evaluated by using Sorensen's coefficient of similarity: \( S = 2a/(2a+b+c) \), where \( a \) is the number of species common to both sites and \( b \) and \( c \) are the number of species occurring on each of the site (see Legendre, Legendre, 1983). The similarity matrix resulting from pair-wise calculations was then subjected to single and complete linkage clustering as well as unweighted arithmetic average clustering (UPGMA; NTSYS program, version 1.70, Net Technology Systems, Eculty, France). The results obtained by these approaches being all very similar, we constructed dendrogram using UPGMA. The accuracy of each cluster was estimated by bootstrap analysis using statistical program FreecTree (Pavlíček et al., 1999). A dendrogram was deduced from 1000 bootstrap samples.

The results of analysis of Carabidae fauna in all sites are shown in Fig. 1. There are two main branches in dendrogram: one of them consists of grassland and different types of secondary forest (sites No 1, 2, 6, 7), and another united primary forest ecosystems (sites No 3, 4, 5, 8). The diversity of Carabidae varied in first group from 9 to 21 species, in second group from 4 to 10 species for each site.

![Fig. 1 Similarity of 59 Species of Carabidae Collected by Pitfall traps Among 8 Sites in Russia. Bootstraps Probabilities (expressed in percentage) are Indicated at the Node of Each Cluster](image)

**Conclusions**

The insect fauna of Russian Far East is represented by about 31500 species. Insects are best and well represented at the family and species levels in Primorski krai, mostly in its southern part.

A one hectare plot has been established in the forest near Ussuriiskii Natural Reserve in Primorski krai in 2001 as a core site. The 33619 specimens of arthropods from 118 samples have been collected totally in plot using 7 trapping methods. Beside 31 recorded from Primorski krai insect orders only 19 were found in the plot. The most abundant orders are Diptera (52% of specimens) and Lepidoptera (26%). In plot the number of families of the large orders, such as Coleoptera, Diptera and Trichoptera, amounts to 30-40% of the total number of families in Primorski krai.

The number of species in plot varied from 4-9% (Coleoptera, Orthoptera, Ephemeroptera, Trichoptera) to 18% (Hymenoptera: Formicidae) or 39% (Diptera: Drosophilidae) of the fauna of Primorski krai, therefore the estimated number of insect species of the plot in core site at Kamenushka is calculated at about 1100-2250.

Seven satellite sites was studied at vicinities of Vladivostok in 2003. Totally 7427 specimens of arthropods were collected by pitfall traps. All specimens of family Carabidae (Coleoptera) were determinate to species. The preliminary analysis of the ground beetles fauna show, that biodiversity of the primary, non-destroyed forest ecosystem is less than the diversity of the secondary forest, the forest under strong human press, or grasslands.
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