Invertebrates of the sandy coastal habitats in Latvia

VOLDEMARS SPUNGIS

Department of Zoology and Animal Ecology, Faculty of Biology, University of Latvia, 4 Kronvalda Blvd., LV-1586, Riga, Latvia; e-mail: adalia@lanet.lv

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Abstract: Seacoasts possess rather high diversity of habitats in a limited area arranged as narrow lines parallel to coastline. Every habitat has a specific invertebrate fauna. The diversity of habitats and microclimate generally favours to the establishment of a rich fauna there. Saprophagous, phytophagous, particularly nectarophagous, zoophagous, disseminating species and occasional visitors are the main ecological groups of insects found there. Few insect species are specialised to live in specific conditions there and they can be used to indicate the biological value of coastal habitats. The fauna in the front of the foredunes is less rich in species, but individuals. The fauna behind foredunes is richer in species, but individuals. Insect diversity reaches a maximum on the foredunes and in the wet areas of the beach. Extensive diurnal activity and dissemination of species take place.

Key words: coastal habitats, sandy beaches, invertebrates, biodiversity.

Introduction

Coastal ecosystems occupy almost 500 km of the Baltic Sea coast of Latvia, represented mainly by sandy beaches and dunes formed by small-grained sand. About 60% of the coastal ecosystems have remained relatively unchanged while the rest is exposed to human activities. The Western part of the Latvian coast and the Eastern part of the Gulf of Riga is exposed to wind and forms a high energy beach. The Western part of the Gulf of Riga is in contrary accumulative, low energy beach. The coastal conditions are stable there during the summer allowing those species with short life cycles allow to reproduce.

From shore to further inland steep gradients of specific abiotic factors exist. These gradients are usually wind, salt spray and nutrients and are reflected in typical vegetation zones (Koehler, 1998). These gradients are smoothened in Latvia. Coastal habitats provide a variety of relief, microclimate and habitats, thus influencing breeding, distribution and migration of insects (Packham, Willis, 1997). The seacoast is also a sharp border to the distribution of insects, and interference zone of marine and terrestrial life.

If there is enough sand transported ashore it is blown over the beach and trapped by plants. Dunes are built under the influence of plants and soil biota. They are young and fragile ecosystems that can be affected by even weak recreational pressure. Coastal lagoons, embryonic and white dunes with *Ammophila arenaria* are found in Latvia and are endangered in Europe (Council Directive 92/43/EEC).

Very few ecological investigations on invertebrates, particularly on insects, have been performed in coastal habitats, particularly dunes (Brown, McLachlan, 1990, Lyneborg, 1992, Atkinson, Houston 1993). Insufficient attention has also been

paid to the insects of the seacoast interference zone and on the flying insects. Scientists have concentrated mainly on collecting invertebrates by pit-fall traps and on large specimens that can be collected one by one (Atkinson, Houston, 1993). These are beetles, spiders and less numerous other groups.

The diversity of different organisms has been studied at representative sites along all Latvian shoreline. V.Melecis et all. (1997) investigated Diptera and other flying insects in coastal meadows and some dunes. Insects in coastal meadows, soil microarthropods in dunes and drift-line have also been studied in Latvia (Melecis et all., 1997, Pauliņa et all., 1998). Beetles were studied by M.Stiprais (1988) during the spring activity period.

Hypothesise, species diversity and abundance on the beech should increase towards inland, since the harshness of environmental conditions decreases. Sea litter dependant species should be less abundant inland, while inland species should be scarcer at the coast. The dominance of species should be higher close to the sea, because of more extreme conditions, and should become lower inland. To validate these hypotheses the investigation of species composition, abundance and distribution along a gradient from the water line to brown dunes was performed.

Methods

Observations were carried out at the Baltic Sea coast at Kolka Peninsula, 2 km south of Kolka village in July of 1997, 1998, 1999 and 2000. SW to W winds dominate throughout the year. So, the investigation site is sheltered from direct prevailing winds year round. The study site represents a low energy beach with limited wind and wave impact. The selected section of beech is composed of fine sand and sheltered from the predominant winds. The width of the beach is about 25-30 meters. The coast is overflowed with brackish marine water during the autumn storms, and is considerably stable during the summer months. Ground-water release in some places is filling up the temporary lagoons with freshwater. The lagoons are formed by co-operative action of wind, sea currents and transported sand material. The sea in the vicinity is quite unpolluted and algal blooming was not observed during the study.

Insects were collected along the transect starting at the waterline, ending at white and brown dunes (fig. 1). Direct observations, sweep-netting, pitfall traps, toad droppings and tracks on sand left by animals were used to study the insects and other animals in the selected habitats. No standard method has been applied. More attention was paid to the identification of habitats, prevailing animal groups and interactions and less attention to the identification of species.

Results and discussion

Habitats

The vegetation and plant species composition along the marked transect is typical for the Latvian coasts and indicates well the types of coastal habitats (fig. 1). The habitats are situated parallel to the waterline. They gradually transform from one type to another with no sharp border between them can be observed.

The area from the waterline to the foredunes is mostly unstable and is usually overflowed during storms. The diversity of plant species adapted to coastal conditions is low. Annual herbaceous pioneers like *Juncus bufonius*, *Polygonum hydropiper* and *Cakile maritima* dominate among plants. The

foredune and area behind is rarely affected by waves. Perennial herbaceous plants like *Juncus articulatus*, *Agrostis stolonifera*, *Calamagrostis epigeios*, *Leymus arenarius*, *Ammophila arenaria* and the annual *Sagina nodosa* can establish there. Bushes and trees can only grow on white and brown dunes what are affected by waves only during the storms.

The morphology of the coast as well as the location and size of lagoons changes from year to year.

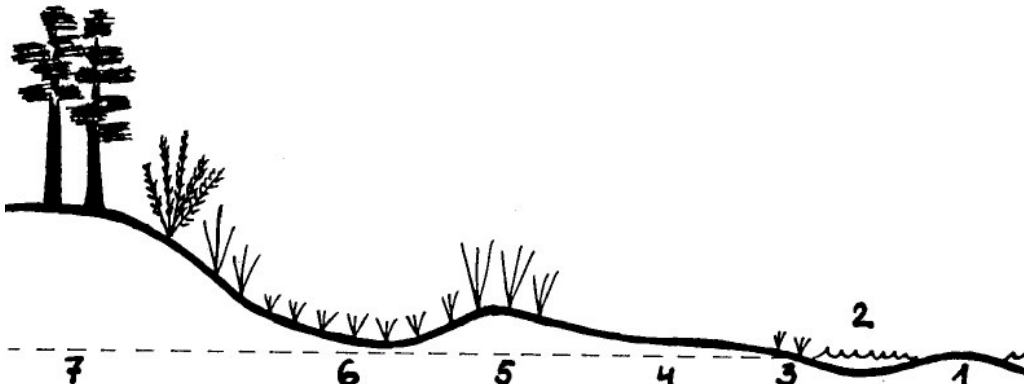

Figure 1. A scheme of the coastal transect and habitats along it: 1 - wet sandy beach and waterline with sea-litter; 2 - shallow lagoon; 3 - moist lagoon margin; 4 - dry sandy beach; 5 - foredune; 6 - area behind foredune; 7 - white and brown dune; dotted line - approximate groundwater table.

Biota of the wet sandy beech and waterline with sea litter

This habitat is frequently overflowed by waves and no vegetation grows there. Sea litter does not form significant mass in the study area. The abundance of sea litter changes during the season and also depends on the level of sea pollution.

Nevertheless, sea litter is a favourable substrate for the development of a complex of insect species, particularly flies. The larvae of Ephydridae, Heleomyzidae, Muscidae, Scatophagidae are main decomposers of this substrate.

The flies appear to be behaviourally adapted to life in windy conditions, for example, short and low flight or an unwillingness to fly. A.C.Brown, A.McLachlan (1990) pointed out that wind resistant species, for instance, a characteristic coastal species *Hydrophorus praecox* are hydrophobic, emerge completely dry after being submerged by the wash, and can crawl without sticking to mucilaginous weed

Biota of the shallow lagoon

The nutrients coming from the sea aid in the development of algae in and around the lagoons. Large gulls (*Larus canus*, *L. ridibundus*, *L. argentatus*) frequently rest on the beach. Some smaller birds (*Motacilla alba*, *Calidris alpina* and others) feed upon invertebrates on the beach. Birds leave droppings and thus enrich the sand with nutrients what promotes the development of algae. Unicellular algae dominate in lagoons, while filamentous algae form low biomass.

Larvae and adults of *Scatophaga stercoraria* (Scatophagidae), *Scatella stagnalis*, *Setacera aurata* (Ephydridae) and Heleomyzidae are the most abundant while

Stratiomys chameleon (Stratiomyidae), Muscidae, Chironomidae and other fly families are also significant decomposers of the algal biomass. The larvae of *Heterocerus fusculus* (Heteroceridae), *Helochares obscurus* and *Cercyon* sp. (Hydrophilidae) also contribute to the decomposition of algae. Flies are the most abundant and are the key insect species in beach food chain (fig. 2).

The crustaceans Ostracoda and segmented worms Naididae also are abundant in the lagoon and can serve as a food source for predaceous invertebrates, for instance, larvae of Dolichopodidae.

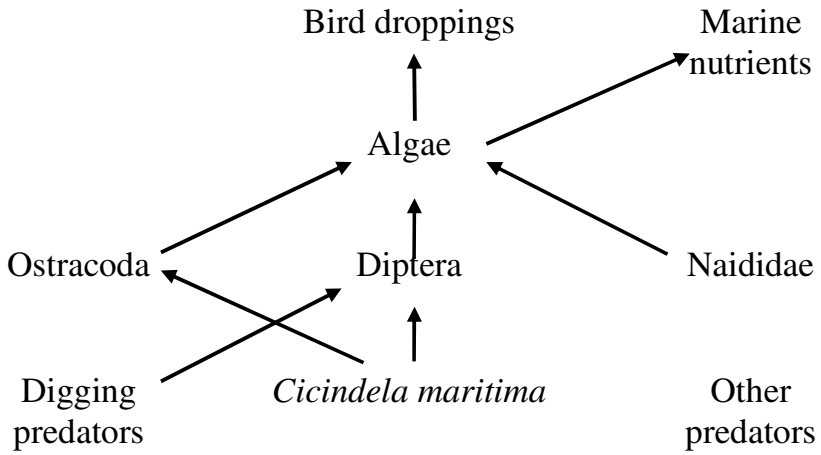

Figure 2. Simplified scheme of the food chains around the lagoon.

Additional to wind resistance, gliding flies sitting on the water surface of the lagoon, particularly Dolichopodidae and Heleomyzidae were observed.

Biota of the moist margin of the lagoon

Moist sandy habitats are formed around lagoons and in places where groundwater is coming out. The habitat is narrow, overgrown with scarce annuals like *Polygonum hydropiper* and *Juncus buffonius*. Only one phytophagous leaf-beetle species *Phyllotreta* sp. (Chrysomelidae) was found on *P. hydropiper*. Unicellular algae grow on top of the sand or 1-2 mm below the surface in dryer places. Insects were not found deeper in sand because of anaerobic conditions there.

There is little difference in the fauna of the lagoons and lagoon margin. Fly larvae develop in the water and pupate on the lagoon margin. So, the margin can be densely covered by freshly emerged flies, which distribute in any direction during the day.

Nevertheless, lagoon margin has specific insect fauna. Digging behaviour is characteristic for the majority of insects what permanently inhabit wet sand. Saprophagous and predaceous species are typically represented by larvae and adults. The algae in and on the wet sand are an important food source for larvae of *Sympecta hybrida*, *Dicranomyia modesta* and *D. frontalis* (Limoniidae). The presence of these larvae is recognised by tracks left on the sand. The mature flies emerge at night and remain among the vegetation during the day as they are not wind resistant. The lagoon margin is also colonised by digging Collembola (*Isotoma* sp.), by larvae and adults of

Heterocerus fusculus and *Cercyon* sp., all of them at low density.

A specific assemblage of digging predatory larvae and adults live in the wet sand around the lagoon. Species include *Omophron limbatum*, *Dyschiriodes globosus* (Carabidae), *Deronectes latus* (Dytiscidae), *Stenus* sp. (Staphylinidae) and the spider *Philodromus fallax* (Thomisidae). Juvenile spiders dig into the sand loosen by other insects. Shore bugs *Salda litoralis* (Saldidae) feed upon springtails. The adults of Dolichopodidae feed upon smaller flies while their larvae feed on different small sized invertebrates in the water or on the wet sand.

In 1998 the mass breeding of the running toad *Bufo calamita* observed. Analysis of the droppings of juvenile animals showed that flies are their main (75%) source of food (fig. 3.).

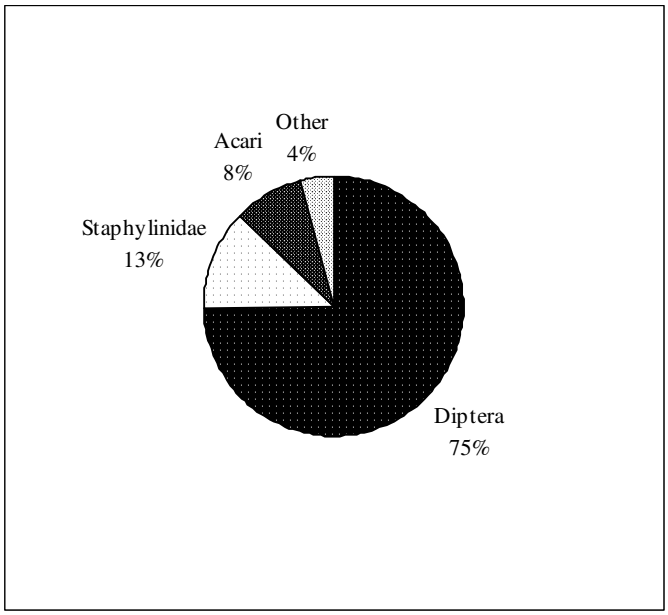

Figure. 3. Food preference of running toad juveniles at t he moist margin of the lagoon at Kolka in July of 1998. Toad droppings were analysed.

Biota of the dry sand beach

This habitat is not covered by vegetation, but in the driest places at the foredune single *Cakile maritima* can grow.

The sandy beach has the lowest species diversity. No phytophagous species were observed, except *Melanostoma scalare* visiting flowers of *C. maritima*. Very few digging saprophagous insects were observed because of their dependence on moisture in the sand.

The flies crossing the area serve as a main food source for adults and larvae of the predatory tiger beetle *Cicindela maritima* (Cicindelidae). The highest number of beetles on the beach was recorded between the wet margin of the lagoon and the foredune. The absence of vegetation cover and exposed sand allow beetles to hunt freely on flies during warm part of the day. Thus, tiger beetles are key species in the coastal food chains as a main consumer of flies. *C. maritima* is also known to pray on coastal Otitidae *Tetanops myopina* (Lindroth, 1998). At night the beetles dig into the dry sand on the foredune and leave the shelter in late morning depending on temperature and precipitation.

Tiger beetle larvae make their holes in the sand only in places where the depth of the ground water table is more than 20-30 cm deep. The density of holes is the highest (up to 45 individuals/m^2) in the wet-stabilised sand close to the foredune and also behind that, but they are absent on the top of the foredune with dry and wind-transported sand. The diameter of the holes corresponds to larval age. In July it is possible to observe holes of different diameter. That can be explained by egg laying during the first half of the summer. Half-developed larvae hibernate (Lindroth, 1998). The larvae are sensitive to trampling of the sand and cannot restore their holes if destroyed. Every year a number of larval holes can be buried by sand during storms. That is the main reason of larval mortality. In summer of 1999 their number was unusually high, but in spring of 2000 there were only few survived larvae on the beach.

Biota of the foredune

The vegetation on the foredune is composed mainly by grasses *Agrostis stolonifera*, *Calamagrostis epigeios*, *Leymus arenarius* and *Ammophila arenaria*. Separate groups of *Juncus articulatus* grow behind while *Cakile maritima* grows in front of the foredune.

The foredune has the highest observed number of species. That is explained by following reasons. The grasses themselves are not highly attractive to plant-feeders. The diversity of phytophages feeding on them is rather low. Aphids (Aphidae) prevail. They can reach outbreak and can serve as prey for a diverse number of aphidophagous species (Chrysomelidae, Coccinellidae, Syrphidae). Exudes of aphids attract nectarophagous insects. Flies *Tetanops myopina* (Otitidae), bugs *Chorosoma schillingi* (Rhopalidae) and *Ischnosoma sabuleti* (Lygaeidae) are common and characteristic consumers of dune grasses. *Cicadella viridis* and other Cicadodea and the bug *Notostira calcaratum* (Miridae) are also common. Meadow species such as locusts (Acrididae) and moths are rare in this habitat.

Dune grasses are usually heavily infected by corn black grain *Claviceps purpurea* (Clavicipitaceae). Exudes of the fungi attract numerous insects (fig. 4). In one sample (25 sweeps) 180 specimens of approximately 50 species were collected. These species represented phytophagous, nectarophagous and saprophagous species like *Corymbia rubra* (Cerambycidae), *Agrypnus murinus* and *Prosternon tessellatum* (Elateridae), species of Anthomyiidae, Cryptophagidae, Lathridiidae, Muscidae, Nymphalidae, Sciomyzidae, Scirtidae, Staphylinidae, Tephritidae, other fly families what are not typically connected to grasses on dunes, and also predaceous and parasitic species of Coccinellidae, Tachinidae, Asilidae, Ichneumonidae, Malachidae, Empididae, Chalcidoidea, *Malthodes* sp. (Cantharidae) and *Demetrias atricapillus* (Carabidae). The majority of exude feeding insects makes diurnal feeding migrations from forest of brown dune to foredune. These species can transfer ascospores from coastal to inland habitats.

The assemblage of predators on the foredune is represented typically by digging species *Anoplius viaticus* (Pompyliidae) and *Ammophila sabulosa* (Sphecidae). At night a rich assemblage of ground dwelling predators and scavengers migrate from the white and brown dune to the foredune (see below). Tiger beetles spend nights burrowed in the dry sand of the foredune, but their larvae occur seldom there.

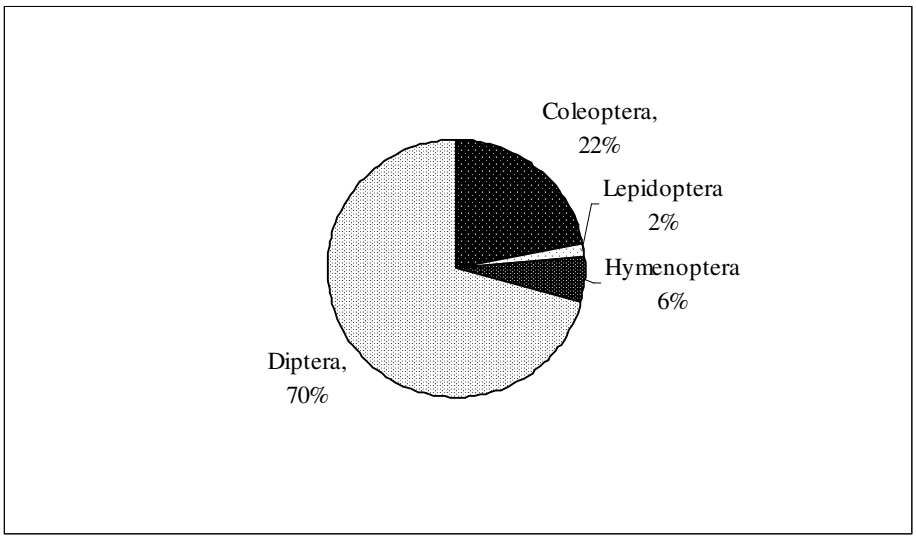

Figure 4. Relative number of species belonging to different insect orders found feeding of corn black grain on foredune grasses at Kolka on July 27 of 1997.

Biota in the area behind the foredune

The plant species composition is similar to that of the foredune. Plants grow in separate groups. *Sagina nodosa* is specific for this habitat, it is an annual herb and forms a continuous cover in July. Nectarophagous insects on *S. nodosa* is represented by *Melanostoma scalare* and other hover flies (Syrphidae), solitary bees and bumblebees (Apoidea) and some other anthophilous insects. Bees come to feed from the nesting sites in the forest on brown dune and have never been observed feeding upon exudes of black grain of corn.

Phytophagous species here are similar to that of the foredune. Dry conditions do not favour ground-dwelling saprophagous invertebrates. Nocturnal crustaceans like *Porcellio scaber* (Porcellionidae) dominate. Necrophagous larvae of *Silpha carinata* (Silphidae) and *Panorpa communis* (Panorpidae) are frequent in this habitat and feed upon dead insects. *Anoplotrupes stercorosus* (Geotrupidae) can be found occasionally.

This habitat has root-stabilised sand and is suitable for the making of holes by tiger beetle larvae. Other psammophylous predators like spider wasps (Pompylidae), solitary wasps (Sphecidae) and *Broscus cephalotes* (Carabidae) are characteristic of this habitat. The assemblage of predators is mainly formed by species that do not live permanently in this habitat, but migrate from the forest on the brown dune. These include *Trechus quadristriatus*, *Calathus melanocephalus*, *Poecilus cupreus*, *Pterostichus anthracinus*, *P. melanarius*, *P. strenuus*, *Amara* spp. (Carabidae), *Staphylinus erythropterus* and Staphylinidae gen. sp., spiders (mainly Lycosidae, Clubionidae), *Formica cinerea*, *Lasius niger*, *Myrmica ruginodis* (Formicidae) and *Phalangium opilio* (Phalangiidae). Most of them migrate diurnally from the brown dune to the foredune. They rarely migrate farther than the foredune.

The soil fauna of this habitat type was not investigated. I.Salmane (1999) reported that this fauna is quite rich.

This habitat is an important feeding ground for the common toad *Bufo bufo*, who is active at night. The food preference includes mainly nocturnal insects (fig. 5).

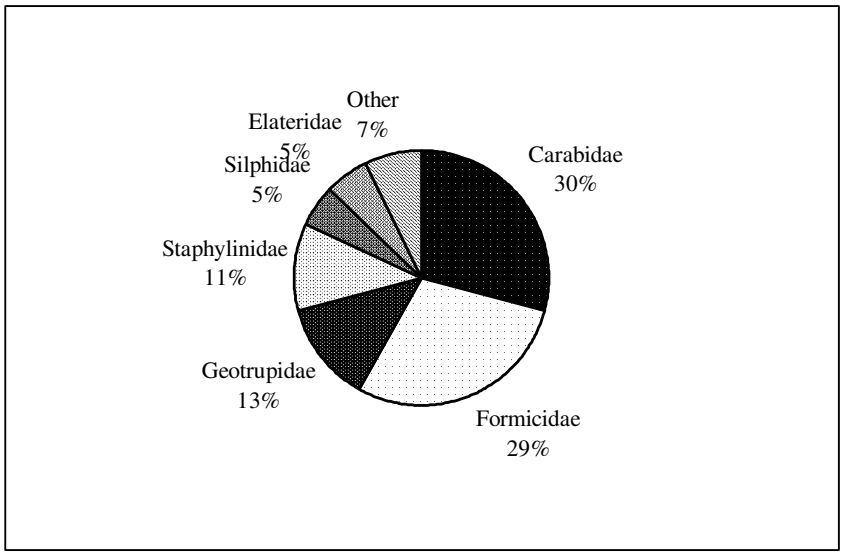

Figure 5. Food preference of common toad adults in the area behind the foredune at Kolka on July 27 of 1997. Toad droppings were analysed.

Biota of the white and brown dune

The front slope of the dune represents a narrow strip of white dune with the same grass species as on the foredune. Conditions there are suitable for establishment of bushes like willows *Salix* spp. and black alder *Alnus glutinosa*. The top of the dune represents a brown dune, about 1.5 m above sea level and is overgrown by Scotch pine *Pinus sylvestris* and other plants that are characteristic of a dune forest.

The insect species assemblage on grasses is similar to that on foredune plants. The phytophagous species that are characteristic for pine forests were not considered here. Only the sawfly *Pontania* sp. (Tenthredinidae) on willows is specific to coastal habitats and is rarely distributed towards the inland.

Brown dunes are a refuge for species what migrate to feed on the beach (see above). Brown dunes are also a refuge for the common and running toad and the Eastern Hedgehog *Erinaceus concolor*. All these animals search for large invertebrates up to the waterline. That was recognised by the analysis of droppings of the common toad. The ground beetle *Omophron limbatum* lives only around the lagoons and was found in toad droppings. Hedgehog tracks have been found at the waterline.

Discussion

Seacoasts possess a rather high diversity of habitats in a limited area arranged as narrow lines parallel to the shoreline. Each habitat type has a specific insect fauna. The diversity of habitats and microclimate favours the establishment of a rich fauna here.

A small number of insect species are adapted to the specific conditions here. Saprophagous, phytophagous, particularly nectarophagous, zoophagous, disseminating species and occasional visitors are the main ecological groups of insects found on the coast. Coastal plants significantly contribute to the stability of sand and therefore promote insect species diversity.

The fauna behind the foredune is more stable and rich while the fauna in front of the

foredune is less stable and is rich in individuals. Insect diversity reaches a maximum at the foredune and in the wet areas of the beach. Extensive diurnal activity and dissemination of species take place. The forests on the brown dune serve as a refuge for species, but that is most probably characteristic only for narrow beaches as in the study area. It is also possible to observe numerous migrating and disseminating non-beach species on the coast. It is, however, only possible to use specialised species as impact indicators and for estimating the trends of coastal habitats.

It was pointed out by other researchers that even though the environmental conditions on beaches and dunes are extreme, there is a high diversity of both widely distributed soil microarthropods, insects, fungi and mosses and habitat specialists (Pauliņa et al., 1998).

Insect species richness of invertebrates is limited by the richness of the vegetation, sea debris and algae growing in the sand and by immigration of individuals. The total number of beech specialist species is rather low. Predominantly they have a short life cycle as in polivoltine flies, rarely they are monovoltine like *Cicindela maritima*.

The insects what are not trophically connected with the coastal habitats are abundant during migration and dissemination. These species perish in the sea and serve as food for predators like insects, birds, amphibians and mammals. Diurnal migration and activity of invertebrates are characteristic for such narrow low-energy beaches.

The observations show that the regeneration potential of species living in an ephemeral habitat is high. Larvae of all species collected in the study can be observed in July from year to year, except in places heavily buried by sand. Presumably, coastal dune forests serve as a hibernation site of coastal insects.

Finally, the specialised coastal plant and animal species can be used as indicators for pressures to coastal habitats, particularly recreation.

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Kopsavilkums

Jūras piekrastes biotopi tika pētīti jūlijā 1997-2000. gados apmēram 2 km uz dienvidiem no Kolkas ciema. Pētījumu vietā ir raksturīga liela biotopu daudzveidība nelielā platībā. Biotopu un mikroklimata dažādība rada labvēlīgus apstākļus bagātas, katram biotopam īpatnējas bezmugurkaulnieku fauna izveidošanos. Galvenās ekoloģiskās grupas ir saprofāgi, fitofāgi, it īpaši nektarofāgi, zoofāgi, sugas, kas izplatās un regulāri migrē, kā arī nejauši viesi. Tikai nedaudzas kukaiņu sugas ir specializējušās dzīvei piekrastē un tās var tikt izmantotas par piekrastes biotopu bioloģiskās vērtības un stāvokļa indikatoriem. Embrionālās kāpas priekšpusē fauna ir sugām nabadzīgāka un īpatņiem bagātāka, bet aiz priekškāpas fauna ir sugām bagātāka un īpatņiem nabadzīgāka. Kukaiņu daudzveidība sasniedz maksimumu uz embrionālās kāpas un pludmales vietās ar peļķēm. Novērota īpatņu diennakts aktivitāte un migrācijas.

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