employed consists of a line of beaters moving toward two or three shooters on fixed stands. Using this system, one party which averaged twenty hunts per year, shot eighteen deer per year for the five-year period, 1952–56.

The sambar are not generally recognized as constituting a serious economic problem to local runholders. The deer provide sport, venison, and salable skins. The meat is sometimes used as food for the farm dogs.

Because of the restricted habitat available to sambar in the sand-hill country, and the constant hunting pressure that is likely to continue with deer unprotected, these animals are unlikely to become a serious threat to future grazing interests in this area. Controlled local shooting has apparently been sufficient to satisfy requirements for protection of young exotic forest trees from sambar.

As scrub land is brought into production, and as swamps are drained, sambar habitat can be expected to decrease. As sand dunes are planted to forest, sambar habitat can be expected to increase. Since the two processes are going on simultaneously, this involves local shifting from scrub areas to exotic forest areas for cover. Unless serious efforts are made to eliminate these animals from the entire area, the sambar should survive further stages of land reclamation.

For help with the Indian records, I am indebted to Mr. McCann of the Dominion Museum; for local records, to Messrs. J. Moreland, Dominion Museum, and G. Caughley, New Zealand Forest Service; and for four sambar records, to the Wellington Branch of the New Zealand Deerstalkers Association. I am particularly grateful to Mr. and Mrs. L. Shailer, and Mr. and Mrs. M. Shailer, of Rongotea, not only for supplying much of the information on sambar, but for kindly allowing me to join with them in the excitement of several of their hunts.

REFERENCES

BRANDER, A. A. D., 1923: *Wild Animals in Central India*, Edward Arnold & Co., London.

——— 1944: Breeding Season of the Indian Sambar. *J. Bombay Nat. Hist. Soc.* 44 (4): 587.

SHAILER, L. C., 1957: The Sambur Deer. *The Roar, Ann. Pub. N.Z. Deerstalker's Ass.* 3: 19.

SIMON, E. S., 1943: Breeding Season of the Indian Sambar (*Rusa unicolor*), Kerr. *J. Bombay Nat. Hist. Soc.* 44 (1): 118-119.

THOMSON, G. M., 1922: *The Naturalization of Animals and Plants in New Zealand.* Cambridge Univ. Press. Cambridge, England.

The Hedgehog Population and Invertebrate Fauna of the West Coast Sand Dunes

R. E. Brockie

It is convenient to divide the sand dunes into three zones, characterized by their vegetation, and the invertebrate fauna, which largely depends on the plants for cover and food, can also be divided into these three zones.

The first of these zones nearest the sea is the belt characterized by a sparse covering of marram grass, beach silver grass or pingao. These plants provide very little cover or insulation and produce no litter; as a result the surface temperature of the sand may fluctuate violently throughout the day. During midsummer it may range from 120° F. to 60° F., but despite this some animals are found here, the most frequently occurring ones being burrowing centipedes and ants, digging wasps (*Salius* spp.), tiger beetles (*Cicindella* spp.) and their larvæ. An important element of this zone is the occasional piece of driftwood or seaweed which gives cover to sandhoppers (*Talorchestia* spp.), the littoral earwig (*Anisolabus littoralis*), slaters, termites, the katipo (*Latrodectus katipo*), the large caterpillars of the sand scarab (*Pericoptus truncatus*), as well as many species of mosquitoes, sand flies and the kelp fly (*Coelopa littoralis*). These invertebrates attract pipits, plovers, sparrows, chaffinches and other birds by day and hedgehogs at night. Slim grass spiders build their webs in the beach grasses and take advantage of the many small dipterans blown in from the foreshore.

The more consolidated sand dunes forming the second zone may have a light covering of marram, lupin and sedges or an impenetrable tangle of lupins and bracken overgrown with tall grasses, *Muehlenbeckia,* and goose grass. This dense cover produces an abundance of litter which provides cover and moisture for the rich invertebrate fauna. The varied texture of the sand and soils, the presence of pines, *Coprosmas,* boxthorns, toi-tois, flax and other shrubs, and great extremes of moisture and temperature, make this a rich habitat for invertebrates. The leaves, flowers, roots, seeds

and litter are each starting points for many interweaving food chains, *e.g.:*

Bracken, lupin and *Muehlenbeckia* leaf litter

↓

Beetle and moth caterpillars, earwigs, mites, millipedes, centipedes, harvestmen, ants, thrips, aphids, slaters, slugs, sandhoppers, Collembola, nematodes, snails

↓

Predaceous beetles and spiders, skinks, blackbirds, thrushes, hedge-sparrows, starlings, rats, weasels, stoats, hedgehogs.

During the summer the most noticeable animals here are the blue butterfly (*Lycaena labradus*), the large copper butterfly (*Chrysophanus salustius*), and smaller copper butterfly (*C. boldenarum*), several species of parasitic and nectar-sucking wasps, the blowflies (*Calliphora erythrocephala, C. hortona,* and *Sarcophaga mulleri*) and many species of midges and flies which move into the zone at different times of the day from aquatic habitats outside the zone. Grasshoppers (*Phaulacridium* spp.) may occur in plague numbers during summer. The cricket (*Gryllulus servilei*) and locust (*Locusta migratoroides*) are also found. Not so noticeable are the many phytophagous and saprophagous moth and beetle caterpillars which thrive on the leaves, litter and roots of the plants. At night a fauna of cryptic animals emerges. Commonest are slaters, sandhoppers, millipedes (probably *Iulus* sp.), and slugs. which are active throughout the year, and snails, ground spiders, adult moths and beetles. whose activities usually stop with death or hibernation in winter. It has been estimated that there may be as many as 8,000 snails per acre even during August.

The third zone coming further inland comprises the grassed dunes. In this zone grazing and trampling by stock and the effects of farming practice have caused larger plants to disappear and be replaced by sward and occasional hedges and islands of shrubs. Cumber (1, 2, 3) operated a light trap near Foxton for a year and caught 233 species of insects. Most of these were moths (108 species), flies (75 species), and beetles (21 species). In some cases it has been possible to estimate the total number of animals per acre in this zone.

Lakes, marshes, and cattle droppings have a fauna of their own and contribute to the number of species in this inner zone.

Hedgehogs

In New Zealand, as in Europe, hedgehogs are very abundant in sand dunes. In one area on the northern outskirts of Paekakariki there are probably more than one hedgehog per acre. The bulk of the hedgehogs' diet consists of invertebrates, and snails provide up to 90 per cent. of their food. During winter when most snails hibernate the hedgehogs turn to millipedes and slugs for their food. The hedgehogs' food requirements drop to below a twentieth during their fitful hibernation and it seems unlikely that many starve to death in the dunes. In summer, when large areas of the dunes dry out, many snails aestivate and the slug population is reduced. At this time of the year hedgehogs are very difficult to find and their disappearance is attributed either to their migration to moister areas or to their going into aestivation.

Invertebrates impinge on hedgehogs as parasites but their effects are negligible.

The abundance of invertebrates can be attributed primarily to the long mild summer, which enables many species to have two or three broods a season; to the loose, well-aerated soil, which provides a good habitat for the many species which spend the earlier stages of their life underground; and to the abundance of litter and the extensive rooting system underlying the varied plant cover, which provides a rich source of food. The invertebrates are kept

Species	*Locality*	*Date*	*No. per sq. ft.*	*Estimated No. per acre*	*Authority*
Cicada—					
Costelytra zealandica	† Man.	Sept./Oct.	(grubs) 1.03	45,000	Cumber and Cowie (5)
Pyronota festiva	† Man.	„ „	(grubs) 3.2	140,000	Cumber and Cowie (5)
Grass grubs—					
Melampsalta cruentata	† Fox.	?	(larvæ) 20–30	1,090,000	Cumber (4)
Helix aspersa	† Pki.	Aug.	*	8,000	Brockie
Slugs (various species)	† Pki.	„	0.8	35,000	Brockie

† Manawatu, Foxton, Paekakariki.

* Average No. 40 per lupin bush.

in check mainly as a result of flooding and by parasitic wasps and flies, which reduce the numbers of subterranean larvæ.

The high level of hedgehog population can also be attributed to the long mild summer, which enables them to have two or three litters a season. Large numbers of snails, millipedes, and slugs provide them with an abundance of food and contribute to their success. It is difficult to estimate which factors hold the hedgehog population in check. There is some evidence which suggests that most hedgehogs die during the winter. This cannot be the result of starvation because of the abundance of food at that time of the year. Predation and parasitism play a negligible role. Diseases such as pneumonia probably play an important part, and it is likely that many hedgehogs are drowned in their nests during hibernation.

REFERENCES

(1) CUMBER, R. A., 1950: *N.Z.J. Sci. Tech.* 32B (1): 2-8.
(2) CUMBER, R. A., 1951: *N.Z.J. Sci. Tech.* 33B (3): 187-190.
(3) CUMBER, R. A., 1953: *N.Z.J. Sci. Tech.* 34B (4): 242-4.
(4) CUMBER, R. A., 1954: *N.Z.J. Sci. Tech.* 36A (1): 60-74.
(5) CUMBER, R. A., and COWIE, J. D., 1954: *N.Z.J. Sci. Tech.* 35A (5): 465-70.

Discussion

The eight speakers of the morning session formed a panel under the Chairmanship of MR. GIBBS, and the discussion, which was inaugurated by N. T. MOAR, took the form largely of questions from the floor and answers by the panel, and the following additional points were covered.

MR. COWIE said that the size of sand grains is controlled by the velocity of the wind: the higher the velocity the larger the grain that can be moved; but he had no special information on wind direction or on average wind velocity. In the north the grains are composed mainly of ferromagnesium and magnetite; south of the Manawatu River you have greywacke and tertiary quartz. On the formation of dunes, he said that in the low rainfall areas, where the regeneration of plants is not good, there will always be some drifting; further south, with increased rainfall, the dunes are more parabolic and tend to be parallel to the foredune. The most stable dunes are parallel to the prevailing wind. Where vegetation has been removed, you get crescent-shaped dunes and not much development of the sand plains. Fairly strong wind, from a steady direction, and patchy vegetation, are necessary for the development of these dunes in this district by blowing out. Where there is an increased supply of sand, and where the wind is stronger, the dunes become longer and stream out inland. The dunes are widest from about Santoft down to the Manawatu River, but further south, with better vegetation and higher rainfall, they seem to be backed up and not to have streamed in so far. He said he had no regular measurements of moisture in the soil. In the wetter parts water would be not more than 2 ft. below the surface; in the higher parts up to 7 ft. below.

MR. HOCKING said, without having actual measurements, he thought the sand was coarser up towards Wanganui, possibly because of the remoteness of the hills further south. On the local effect of vegetation on the water-table, he said you could permanently lower the water-table in wet flats and swamps by planting the surrounding hills in trees, provided water is not creeping in from an extensive source beyond the sand. You might thus change a swamp site into very favourable conditions for growing trees. Where the water is coming in off the back country the trees probably have no effect.

MR. SAXBY said that, because of the differences in vegetation produced by slight variations in the water-table, the farming practice was to sow the same mixture over an area, and it would sort itself out. From the pasture point of view, control of abrasion was very important; crops must be established before sand started blowing. Pasture associations were sometimes sown with very quick-growing annuals so as to lessen the movement of sand and the danger of abrasion to young plants.

C. W. S. VAN KRAAYENOORD described an experiment now in progress to measure the water-table and maximum and minimum temperatures in the soil, and to correlate these with vegetation. He emphasized that, although drains had to be cut in the very wet places, there was very real danger of over-draining; it is possible to spoil 50 acres of good pasture in trying to drain a wet patch of five acres. He suggested that boards might be placed across the drains in September or October to conserve water and retain the level. He spoke of smoothing off dunes into the hollows: he knew a farmer who bull-dozed off the tops with their vegetation, into the hollows, and so improved the organic content of the soil in the bottoms.

N. L. ELDER described a private venture which had met with considerable success in bringing in raupo country in Hawke's Bay. They attributed their success to getting the depth of the drains just right, not getting the peat dried out, or the subsoil drained, too completely.

MR. CARNAHAN said that botanically the dunes do not differ much from Kaipara to Manawatu. In the north *Cassinia retorta* replaces *C. leptophylla*, *Viscaria* disappears, and pohutukawa comes in as climax. Dominants are largely the same and any other changes are very minor.

MR. BROCKIE said the nests of hedgehogs have a general pattern, which may be modified by habitat or available material: usually in a dry depression, sometimes overgrown by dense shrubs, such as flax or lupin, or, in suburban areas, under or behind buildings, they are lined with grass, dried leaves, paper or rags. Nests are sometimes made in rabbit burrows. The hedgehog rolls round until enmeshed, leaving himself no exit. In sand dune country these sites are restricted to gullies