STUDIES ON THE FAUNA OF SURINAME
AND OTHER GUYANAS: No. 19.

A COMPARATIVE STUDY OF THE SOIL FAUNA IN FORESTS AND CULTIVATED LAND ON SANDY SOILS IN SURINAME

by

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1. INTRODUCTION

Studies of the soil fauna of tropical regions are rather scarce. Mainly after the Second World War, several investigations were carried out, both in Africa and in Central and South America (see list of references). These surveys indicated that the fauna is probably less abundant in tropical soils than in temperate soils. Several authors (SALT 1952, DELAMARE DEBOUTTEVILLE 1951) found smaller numbers of microarthropods in tropical soils than in soils of the temperate region, and GOODNIGHT & GOODNIGHT (1956) came to the same conclusion regarding relative numbers after comparison of the macrofauna in a tropical rain forest in Mexico with that of a deciduous forest in Illinois. Finally, SCHALLER (1961), studying the soil fauna in Peru, also remarks that the density of the soil fauna in tropical soils is generally low. Bearing in mind the huge masses of organic debris formed in tropical rain forests and their very rapid decomposition, this fact seems very remarkable.

Notwithstanding its lower density it is generally assumed that in the tropics too, the soil fauna exerts an important influence on the decomposition of organic matter and on the physical properties of the soil (NYE 1961, MALDAGUE 1959, MEYER & LAUDELOUT 1960, CORBET 1935). The alteration in soil fauna accompanying the clearing of forest land and its use as agricultural land therefore seems an important question. This alteration was studied in microarthropods (Acari and Collembola) by MALDAGUE (1958). STRICKLAND (1945) compared the soil fauna in primeval forests and cacao plantations in Trinidad. Both these authors observed a decrease in the soil fauna, dependent on the type of use of the agricultural land.

A grant from WOSUNA, the Netherlands Foundation for the Advancement of Research in Surinam and the Netherlands Antilles, made it possible for the author to study the soil fauna of Suriname, mainly in the coastal region, from April to November 1959.

The chief object was to investigate the composition of the epiedaphic (surface-dwelling) and the hemi- and euedaphic (litter- and soil-inhabiting) macrofauna in primary and secondary forest and in cultivated land (citrus orchards, pastures and fields bearing crops).

The time available for the investigation fell largely in the long rainy period, which in 1959 started in the first part of May and ended in August. It was decided to restrict the observations to forests and cultivated land on sandy soil. Time was too short for the study of more than one soil type, while during the rainy season a study of the lower clay fields would have been nearly impossible. Moreover, on clay substrate it would have been necessary to apply other techniques, for which the equipment was not available.

The experimental areas (fig. 1) were chosen in close cooperation with Mr. F. W. VAN AMSON, M.Sc., soil scientist at the Agricultural

Experiment Station at Paramaribo. They were all situated in the district of Saramacca at distances of 30 to 50 km west of Paramaribo, and were sampled from April till August inclusive. In September, Mr. J. HOLTROP gave the author the opportunity of making a trip to Maripaheuvel, about 130 km south of Paramaribo. There the soil fauna was studied in primary forest and in a field cultivated by bush negroes. In October three stations, which had already been studied in the rainy season, were sampled again to obtain an insight into the composition of the fauna in the dry season.

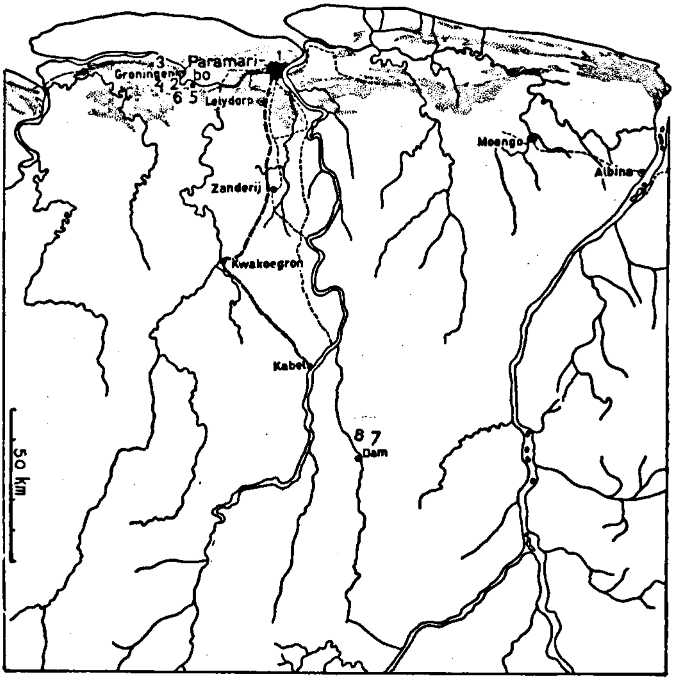

Fig. 1. Map of the north-eastern part of Suriname, showing localities of sampling. The dotted areas represent the sandy ridges.

1. Cultuurtuin at Paramaribo, plots I and II
2. Dirkshoop, plots III, IV and V
3. Tambahredjo, plots VI, VII, VIII and IX
4. Sidoredjo, plots X, XI, XII and XIII
5. La Poulle, plots XIV, XV, and XVI
6. Vank-kolonie, plots XVII and XVIII
7. Maripaheuvel, plot XX
8. Poeroe man Kemisa, plots XXI, XXII, and XXIII

Suriname, formerly Dutch Guyana (capital Paramaribo) is situated on the north-eastern coast of South America, between 2° and 6° lat. N and 54° and 58° long. W. The coastal area, to which the main part of this study is restricted, is about 30 km broad. It belongs to the Demerara formation and consists of Holocene sea and river deposits of clays and fine sands. The sands were deposited as coastal barriers, which now present themselves in the swampy clay areas as somewhat higher ridges ("ritsen"). A minority of these ridges are composed of shells ("schelpritsen", shell ridges).

The natural vegetation of the ridges consists of evergreen seasonal forest with a great number of tree species, varying in height from 15 to 20 m (LINDEMAN 1953).

Parts that have been cultivated at one time are overgrown with dense scrub vegetation or secondary forest, much lower in height than the original forest and in general poorer in species composition.

Large parts of these primary and secondary forests have been reclaimed and are used for growing various annual crops or as citrus orchards and pastures. They are often bordered by the original woodlands, thus enabling the changes in soil fauna, accompanying the reclamation, to be studied.

The temperature in Surinam is high during the whole year round. Average daily maximum and minimum temperatures are 31° and 22.5°C. The warmest months are September and October (mean 27°C), the coldest January and February (mean 25.5°C.) The mean relative humidity varies between 78% in September and 87% in June. The average annual rainfall in Paramaribo is about 2300 mm. There are two rainy seasons, a short one (December-January, with monthly means of about 220 mm) and a long one (from May until August, with a mean rainfall of 250–300 mm per month). Between these rainy seasons there are dry periods. September and October are the driest months, with about 75 mm rainfall each.

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The Director and staff of the Agricultural Experiment Station, especially Mr. F. W. VAN AMSON, M.Sc., are thanked for their help and advice in selecting the areas, and thanks are also expressed to Mr. P. H. VAN DOESBURG for his willingness to place the services of his assistant, Mr. BOHLA, at the author's disposal.

Special acknowledgement is due to those who have made their taxonomical knowledge available to the author: Mr. C. A. W. JEEKEL (Diplopoda), Professor P. REMY (Pauropoda, Uropygi), Dr. S. ENDRÖDI (Scarabaeidae), Mr. P. ARDOIN (Tenebrionidae), Dr. W. W. KEMPF O.F.M. (Formicidae), Professor K. SCHEDL (Scolytidae) and Dr. C. O. VAN REGTEREN ALTENA (Mollusca).

Papers devoted to part of this material have already been published by ARDOIN 1962 (Tenebrionidae), ENDRÖDI 1962 (Scarabaeidae), KEMPF 1961 (Formicidae), MASSOUD 1963 (Poduridae), VAN REGTEREN ALTENA 1960 (Mollusca), REMY 1961 (Uropygi), and SCHEDL 1963 (Scolytidae). Others are in preparation.

2. METHODS

Two main methods of sampling were applied. The surface fauna i.e. that part of the soil fauna which moves freely on the ground, was caught in pitfall traps. These traps consisted of a polyethylene funnel (diameter 17 cm, depth 13 cm), opening into a 100-cm^3 jar connected to the funnel by a rubber ring. The jar was filled with about 25 cm^3 of 70% ethylene alcohol.

The traps were sunk in the ground with the rim of the funnel on a level with the surface. In order to prevent rainwater from flooding the traps, a horizontal circular plate, 25 cm in diameter, was placed over and just clear of the funnel, and supported by three pins. In general, six traps were exposed simultaneously in each of the fields to be compared. After a week, the jars were collected and replaced by new ones. In some cases, traps had been displaced over a short distance but there was no apparent difference between the catches in these traps and those in which traps had not been shifted. The "haul" from one trap in one week was taken as the sampling unit. Two weeks of trapping gave a satisfactory impression of the composition of the surface fauna, and, by comparing the results of simultaneous catches in adjacent fields with varying ecological conditions, the differences or similarities between specified groups could be ascertained. These samples were termed a-samples, and were, in general, composed of twelve sampling units.

Another method of sampling was used for the genuine soil and litter fauna. The b-samples consisted of about 3 litres of litter. They were put in big Tullgren funnels and desiccated by means of-carbon filement bulbs giving a maximum temperature of 40° C, in order to collect the arthropod fauna.

C-samples were taken by means of a steel cylindrical core sampler with a surface area of 100 cm^2, working to a depth of 5 cm. They were desiccated in small Tullgren funnels. The desiccation was completed after 2–4 days, depending on the water content of the sample. Only the macroarthropods were counted in these samples. Five pairs of c-samples were taken when the pitfall traps were installed, and another five pairs a week later when the collecting jars of the traps were changed.

One sample from each of the five pairs was treated separately in a

Table 1

Surface Fauna in different Stations.

Numbers in twelve traps during two weeks. 1959

	Paramaribo Culture garden		Dirkshoop Primary Forest				Dirkshoop Experimental garden		Tambahredjo		Tambahredjo	
	Ia 1–6 shell ridge 14–21 April	IIa 1–6 footland, sand 14–21 April	IIIa 1–6 sand 29 April–6 May	IIIa 7–18 sand 13–27 May	IIIa 19–24 sandy loam 3–11 June	IIIa 25–30 heavy sandy loam 3–11 June	IVa 1–12 citrus, sand 29 Apr.–13 May	Va 1–12 fallow (ground-nut), sand 13–27 May	VIa 1–12 wood, shell ridge 11–24 June	VIIa 1–12 tomato, shell ridge 11–24 June	VIIIa 1–12 marshy wood, sand 24 June–8 July	IXa 1–12 tomato, sand 24 June–8 July
	1	2	3	4	5	6	7	8	9	10	11	12
Oligochaeta	18	.	.	.	.	.	3	.	65	3	16	2
Gastropoda	2	2	.	.	.	.	.	.	3	4	1	6
Isopoda	12	2	2	4	.	2	18	.	120	64	10	54
Araneïda (–)	22	4	20	19	4	12	36	11	15	7	5	27
Lycosidae	6	56	2	1	2	2	34	53	1	3	1	39
Chernetes	.	.	2	1	.	.	1	.	3	3	.	.
Diplopoda	.	.	2	5	.	4	.	1	4	2	.	5
Orthomorpha coarctata	128	94	.	.	.	.	.	.	107	54	15	1
Polydesmidae	2	.	.	.	.	.	.	.	.	2	.	.
Stemmiulus surinamensis	.	.	12	5	6	2	.	.	.	.	7	.
Rhinocricus monolicornis	2	4	.	12	.	.	3	2	53	13	97	7
Epitrigoniulus cruentatus	.	.	8	12	2	.	.	.	.	.	.	.
Trigoniulus lumbricinus	4	.	.	.	.	.	.	.	.	.	.	.
Orthoporus flavicornis	.	.	.	2	.	.	1	.	9	3	19	3
Plusioporus oyapokanus	.	.	6	19	2	.	4	.	26	1	.	.
Gymnostreptus	.	.	42	106	186	26	10	.	41	.	10	.
Nanostreptus grayi	.	.	.	.	.	.	.	.	.	.	47	.
Siphonotus	10	.	12	1	.	.	2	41	.	2	9	8
Chilopoda	4	4	.	1	.	.	1	.	.	.	3	2
Entomobryidae	230	4	156	31	8	2	260	8	160	176	59	84
Acridiidae	.	.	.	.	.	.	.	2	.	.	.	.
Blattidae	.	.	.	6	2	.	2	.	7	.	.	1
Gryllidae	6	34	24	25	20	18	12	30	19	19	3	44
Gryllotalpidae	4	2	.	.	2	.	.	16	.	2	.	9
Dermaptera	.	.	12	17	12	70	.	.	4	.	.	.
Isoptera	.	.	.	1	14	12	.	1	3	.	.	.
Heteroptera	14	.	30	34	34	6	8	8	23	5	7	39
Homoptera	.	.	8	27	2	4	23	10	2	11	5	15
Lepidoptera	4	6	.	2	2	.	2	6	.	.	2	1
Coleoptera larv.	.	.	20	6	14	8	18	6	23	12	24	14
Coleoptera im. (–)	174	30	28	38	38	40	59	27	154	35	45	413
Taeniolobus	8	16	.	.	.	.	1	42	.	.	.	2
Brachynus	.	2	88	18	6	.	2	.	7	.	4	.
Pheropsophus	.	4	.	.	.	.	.	184	.	9	.	17
Megacephala	.	.	.	.	.	.	.	110	.	.	.	.
Staphylinidae	12	2	250	47	54	22	24	50	105	6	58	32
Elateridae	114	216	.	.	.	.	33	84	.	.	.	24
Scolytidae	14	10	280	650	194	274	45	420	500	208	575	214
Diptera	.	.	.	.	.	.	.	.	2	.	1	.
Formicidae	436	460	88	75	56	52	758	221	700	167	264	379
Macrofauna non Arthropoda	20	2	.	.	.	.	3	.	68	7	17	8
Arthropoda non Insecta	190	164	108	188	202	48	110	108	379	154	223	146
Insecta	1016	786	984	977	458	508	1247	1225	1709	650	1047	1288
Arthropoda excl. Form., Scol., *Pher.*	756	476	724	440	410	230	554	508	888	420	431	824
Total macrofauna	1226	952	1092	1165	660	556	1360	1333	2156	811	1287	1442

Sidoredjo				La Poulle			Vank-kolonie		Boven Sarakreek				Dirkshoop			Tambahredjo		Vank-kol.
Xa 1–12 shrub, shell ridge 8 July–5 Aug.	XIa 1–12 water melon, shell ridge 8 July–5 Aug.	XIIa 1–12 shrub, sand 8 July–5 Aug.	XIIIa 1–12 water melon, sand 8 July–5 Aug.	XIVa 1–12 shrub, sand 5–19 August	XVa 1–12 pasture, sand 5–19 August	XVIa 1–12 water melon, sand 5–19 August	XVIIa 1–6 shrub, sand 19–26 August	XVIIIa 1–6 pasture, sand 19–26 August	XXa 1–12 prim. forest, sand 4–11 and 15–22 Sep.	XXIa 1–12 prim. forest, sand 4–18 September	XXIIa 1–12 field 1st year, sand 4–11 and 18–24 Sep.	XXIIIa 1–12 field 2nd year, sand 11–18 and 18–24 Sep.	D IIIa 1–12 as IIIa 7–18 30 Sep.–13 Oct.	D IVa 1–12 citrus, sand 30 Sep.–13 Oct.	D Va 1–12 fallow (ground-nut), sand 30 Sept.–13 Oct.	D VIa 1–12 wood, shell ridge 13–26 October	D VIIa 1–12 tomato, shell ridge 13–26 October	D VIIIa 1–12 pasture, sand 13–26 October
13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	13	6	1	4	.	6	.	2	1	2	1	.	.	.	.	.	.	.
21	57	1	3	1	.	1	.	.	.	.	.	.	.	1	.	10	10	.
1515	43	110	19	3	5	8	6	10	1	6	.	.	4	21	.	8	22	3
13	3	8	6	37	23	25	28	20	14	11	11	9	12	44	45	10	12	43
.	1	.	8	2	25	43	6	36	2	.	99	83	1	12	8	.	135	30
.	1	.	.	.	.		12	2	4	2	4	4	2	1	.	1	.	.
.	.	.	.	.	.	.	2	.	3	2	.	.	.	.	.	2	1	.
15	5	9	43	5	.	.	.	.	.	.	.	.	.	.	6	5	128	.
.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	.
5	.	.	.	5	.	.	.	.	.	.	.	.	18	.	.	1	.	.
120	59	5	12	.	.	.	.	2	.	.	.	.	4	2	2	10	13	.
1	.	.	.	.	.	.	.	.	.	.	.	.	10	.	.	.	.	.
2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
49	7	7	2	5	1	4	10	6	.	.	.	.	4	3	1	2	5	1
1	.	.	.	3	.	.	.	.	.	.	.	.	33	12	8	106	11	2
190	3	96	36	11	.	.	4	.	.	.	.	.	150	38	21	1	1	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9	5	4	1	4	2	42	.	.	.	.	.	.	.	13	1	.	1	.
.	.	.	.	.	.	.	.	.	1	1	.	.	.	3	.	.	3	.
390	150	44	64	49	3	170	88	36	190	143	104	64	108	59	77	21	12	39
.	.	.	3	1	4	3	.	6	.	.	4	4	5	.	.	.	1	2
19	1	2	.	11	.	3	14	.	10	15	4	11	3	.	2	12	3	2
16	12	17	28	3	7	26	2	10	19	44	40	56	33	12	28	3	26	17
.	3	1	1	.	14	8	2	.	.	.	3	.	3	2	4	.	2	2
.	.	.	.	168	.	2	134	2	10	13	1	.	70	14	.	1	.	.
1	.	.	.	.	.	.	2	.	46	50	1	2	2	8	1	1	.	.
7	6	2	10	16	3	31	12	36	1	8	14	9	8	19	21	12	9	37
.	5	1	1	7	17	35	10	38	14	9	19	6	5	2	21	14	1	6
3	4	.	.	.	1	5	6	6	.	1	4	3	6	2	3	.	5	4
7	5	15	11	7	2	12	22	14	2	6	3	4	5	18	3	.	1	1
126	25	56	15	17	30	48	52	120	66	84	33	25	16	21	20	110	38	41
.	.	.	.	.	40	34	.	60	.	.	.	.	.	1	.	.	.	9
2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7	677	.	34	.	233	17	.	56	.	.	140	10	.	.	2500	.	375	572
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6	7	9	5	50	33	27	82	20	57	102	47	47	74	4	33	1	1	3
4	35	17	73	.	64	84	4	332	.	.	50	53	.	14	53	2	88	110
242	530	225	269	126	72	20	148	116	1170	146	101	62	382	49	21	1107	215	115
.	2	.	.	.	.	.	.	.	.	6	3	.	.	.	.	.	.	1
164	229	163	226	128	508	247	832	610	211	94	462	588	178	1042	1676	82	376	611
22	70	7	4	5	.	7	.	2	1	2	1	.	.	1	.	10	10	.
1920	133	239	127	75	56	122	68	76	25	22	57	26	238	149	92	146	222	79
994	1692	552	740	583	1031	772	1410	1462	1796	721	1033	944	898	1267	4463	1366	1155	1574
2501	389	403	338	404	274	610	498	756	440	503	387	310	576	325	368	323	411	355
2936	1895	798	871	663	1087	901	1478	1540	1822	745	1091	970	1136	1417	4555	1522	1387	1653

Table 2

Soil Fauna in different Stations

Numbers in ten samples of 1 dm^2 each

1959

	Paramaribo Culture garden		Dirkshoop Primary forest				Dirkshoop Experimental garden		Tambahredjo		Tambahredjo	
	Ic 1–5 shell ridge 14 Apr.	IIc 1–5 woodland, sand 14 Apr.	IIIc 1–10 sand 29 Apr., 6 May	IIIc 11–20 sand 13, 20 May	IIIc 21/25, 31/35 sandy loam 3 June	IIIc 26/30, 36/40 heavy sandy loam 3 June	IVc 1–10 citrus, sand 29 Apr., 6 May	Vc 1–10 fallow (ground-nut), sand 13, 20 May	VIc 1–10 woodland, shell ridge 11, 17 June	VIIc 1–10 tomato, shell ridge 11, 17 June	VIIIc 1–10 wood, sand 24 June, 1 July	IXc 1–10 tomato, sand 24 June, 1 July
	1	2	3	4	5	6	7	8	9	10	11	12
Oligochaeta	*4*	*4*	10	15	15	14	*16*	*1*	22	*16*	12	.
Gastropoda	.	.	.	1	.	2	*2*	.	17	*4*	3	.
Isopoda	*42*	*48*	10	1	2	2	*46*	.	319	*18*	59	.
Araneïda	.	*10*	23	10	18	10	*7*	*11*	13	*3*	4	*2*
Chernetes	.	.	1	.	.	.	.	.	400	*68*	1	.
Symphyla	.	*4*	28	32	49	33	*46*	*3*	70	*2*	57	.
Diplopoda	*16*	.	34	35	33	7	*1*	*3*	44	*3*	6	.
Polyxenidae	.	.	9	6	18	14	.	.	9	.	5	.
Glomeridesmus	.	.	3	1	2	1	.	.	.	.	.	.
Onciurosoma	.	.	1	.	.	2	.	.	1	.	.	.
Poratia digitata?	.	.	.	.	9	5	*2*	.	1	.	4	.
Stemmiulus	.	.	.	1	9	7	.	.	.	.	3	.
Geophilomorpha	*4*	.	1	1	4	3	.	.	4	*5*	.	*1*
Scolopendromorpha	.	.	1	.	3	2	*1*	.	6	.	1	*1*
Campodeidae	.	.	13	3	11	21	.	.	33	*1*	2	.
Japygidae	*10*	*22*	.	.	.	.	*45*	.	14	*14*	2	*2*
Protura	.	.	.	.	.	3	.	.	.	.	.	.
Entomobryidae	.	.	6	4	5	1	*22*	*1*	4	*1*	13	*1*
Isoptera	.	.	8	.	3	31	*4*	.	1	.	2	*2*
Psocoptera	.	.	.	1	18	17	*3*	*6*	44	*33*	85	*30*
Thysanoptera	.	.	4	1	2	.	*2*	*9*	.	.	.	.
Heteroptera	*2*	*4*	4	3	1	1	*3*	*1*	2	*3*	6	*5*
Homoptera	.	.	11	3	19	3	*17*	*5*	6	*7*	10	*7*
Lepidoptera	.	.	1	3	3	2	*3*	*1*	1	.	96	*4*
Coleoptera larv.	*48*	*14*	25	12	15	54	*11*	*65*	20	*13*	15	*7*
Coleoptera im. (–)	*24*	*16*	35	38	25	22	*14*	*15*	20	*5*	27	*7*
Staphylinidae	*10*	*2*	56	39	37	57	*3*	*18*	10	*1*	35	*4*
Elateridae larv.	*32*	*36*	.	.	.	.	*2*	*13*	.	.	1	*1*
Elateridae im.	*6*	*8*	1	.	1	.	*2*	*1*	.	.	.	.
Scolytidae	*4*	*4*	4	.	.	3	*4*	*1*	2	*4*	2	*1*
Diptera larv.	*8*	.	11	3	7	36	*3*	*12*	17	*7*	13	*90*
Formicidae	*364*	*416*	1034	103	608	168	*147*	*37*	172	*22*	109	*38*
Macrofauna non Arthropoda	*4*	*4*	10	16	15	16	*18*	*1*	39	*20*	15	.
Arthropoda non Insecta	*62*	*62*	111	87	147	86	*103*	*17*	867	*99*	140	*4*
Insecta	*508*	*522*	1213	213	755	419	*285*	*185*	346	*111*	418	*199*
Arthropoda excl. Form.	*206*	*168*	290	197	294	337	*241*	*165*	1041	*188*	449	*165*
Total macrofauna	*574*	*588*	1334	316	917	521	*406*	*203*	1252	*230*	573	*203*

Sidoredjo				La Poulle			Vank-kolonie		Boven Sarakreek				Dirkshoop			Tambah-redjo		Vank-kol.
Xc 1–10 Kapoeweri, shell ridge 8, 15 July	XIc 1–10 water melon, shell ridge 8, 15 July	XIIc 1–10 Kapoeweri, sand 15, 21 July	XIIIc 1–10 water melon, sand 8, 15 July	XIVc 1–10 Kapoeweri, sand 5, 12 August	XVc 1–10 pasture, sand 5, 12 August	XVIc 1–10 water melon, sand 5, 12 August	XVIIc 1–5 Kapoeweri, sand 19 August	XVIIIc 1–10 pasture, sand 19 August	XXc 1–5 primary forest, sand 23 September	XXIc 1–5 primary forest, sand 23 September	XXIIc 1–5 field 1st year, sand 23 September	XXIIIc 1–5 field 2nd year 23 September	D IIIc 1–10 primary forest, sand 30 Sep., 7 Oct.	D IVc 1–10 citrus, sand 30 Sep., 7 Oct.	D Vc 1–10 (fallow ground-nut), sand 30 Sep., 7 Oct.	D VIc 1–10 woodland, shell ridge 13, 20 October	D VIIc 1–10 tomato, shell ridge 13, 20 October	D XVIIIc 1–10 pasture, sand 13, 20 October
13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
14	33	3	2	2	5	12	4	32	2	2	2	.	.	1	.	.	.	.
17	2	2	2	1	.	.	.	.	.	2	.	.	.	.	.	28	8	.
102	1	80	.	6	.	26	54	2	4	.	.	.	.	14	.	95	190	.
18	4	17	.	56	7	8	52	9	20	16	12	4	17	10	1	7	4	1
270	430	.	.	.	.	1	6	.	16	10	.	2	1	.	.	260	47	3
6	1	8	2	52	.	59	78	.	48	28	.	10	48	39	.	29	1	.
10	.	10	3	8	.	2	.	.	.	.	.	.	33	5	1	11	49	2
.	.	.	.	.	.	.	.	.	2	2	.	.	7	.	.	6	24	.
.	.	.	.	7	.	.	4	.	.	.	.	.	.	.	.	.	.	.
.	.	1	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	22	2	21	1	3	6	.	18	6	.	.	7	36	.	.	6	.
2	.	.	.	5	.	.	2	.	6	4	.	.	7	.	.	1	.	.
4	1	.	1	.	.	.	4	.	36	6	.	.	2	.	.	3	.	.
1	5	1	1	6	.	.	.	.	2	2	.	.	5	1	.	1	2	.
14	5	17	1	27	.	1	30	.	60	14	.	2	7	.	.	6	.	.
7	12	24	4	8	.	.	26	.	68	22	2	4	1	16	1	14	45	.
.	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2	.	12	.	3	1	.	.	.	16	12	4	8	.	.	1	3	.	2
11	.	2	.	4	14	2	4	2	142	94	.	.	.	6	.	.	.	1
31	14	12	21	2	5	.	2	2	16	6	6	.	3	6	4	.	2	17
.	.	1	.	5	1	25	26	5	.	2	.	2	2	.	1	1	.	1
14	5	6	6	11	12	14	28	32	.	.	4	12	17	1	2	3	.	4
37	14	27	16	12	27	8	2	4	.	2	.	10	2	4	.	2	10	4
.	.	.	2	.	3	.	.	.	.	.	.	.	4	8	.	1	9	8
4	2	71	98	22	37	68	56	37	.	8	2	2	13	9	3	.	2	16
14	3	30	12	39	49	116	22	50	2	2	4	4	28	18	6	16	7	81
4	.	23	7	13	4	35	54	13	4	.	.	.	3	2	1	3	5	14
.	.	.	4	1	20	28	.	20	.	.	2	4	.	.	5	.	12	43
.	.	.	.	.	2	13	6	5	.	.	2	.	.	.	2	.	5	.
6	4	.	2	8	2	1	4	.	6	2	.	.	.	1	1	2	.	1
4	3	37	258	19	54	37	20	52	4	2	2	14	1	2	2	1	.	1
118	7	181	66	104	350	34	152	12	154	210	.	4	81	263	10	91	13	17
31	35	5	4	3	5	12	4	32	2	4	2	.	.	1	.	28	8	.
413	442	139	9	165	8	99	206	11	152	74	12	16	127	105	2	413	323	6
266	69	449	497	278	581	382	432	234	472	376	28	66	162	336	39	143	110	210
561	504	407	440	339	239	447	486	233	470	240	40	78	208	178	31	465	420	199
710	546	593	510	446	594	493	642	277	626	454	42	82	289	442	41	584	441	210

Tullgren funnel. The other five samples were bulked and dried in a big Tullgren apparatus. These are indicated as d-samples, and served mainly for additional material.

The method practised does not give a complete picture of the soil macrofauna. The techniques used are not equally appropriate for all groups. Moreover, several groups live at greater depths than the upper 5 cm.

There are some indications that in tropical soils the fauna extends to deeper layers than in temperate soils (SALT 1952, STRICKLAND 1945, BELFIELD 1956). From the studies of these authors, however, it is apparent that the upper 5 cm layer is the most densely populated region, certainly in the rainy season. Since sampling to greater depth would have affected results only slightly (probably with the exception of those relating to Symphyla), and would have taken too much time, it was decided to restrict attention to the top 5 cm.

3. RESULTS

The differences between the soil fauna in woodland and in cultivated land were studied at seven stations.

Tables 1 and 2 give the results of the total counts in a and c-samples, respectively. In those cases where six a-samples (catches from six traps during one week) instead of twelve were studied (stations I, II, XVII and XVIII), the numbers found were doubled to assist comparison. The same applies to the c-samples of stations I, II, XVII, XX, XXI and XXII, where five instead of ten samples were desiccated. At the head of the columns the exact number of samples is given. These totals will suffice for the purpose of this paper – viz., to present the differences between the animal populations in woodland and in cultivated land. The detailed counts of the individual samples have been recorded in hand-written tables and deposited in Itbon's files.

The animals were grouped in rather high taxonomic units, i.e. orders. Lower units – families or even species – were only distinguished when they occurred frequently and in large numbers of individuals, and these could be identified with certainty. However, in the Diplopoda most of the species are mentioned, thanks to the ready collaboration of Mr. C. A. W. JEEKEL in an early stage of the work.

Experimental garden at Paramaribo

At this station the techniques to be used were tested.

Plot I was on sandy soil with a humus content of 4.4%, rather rich in shell fragments (8.4% $CaCO_3$) and with a pH of 7.3. Dense weed vegetation, about 2 m high, covered the soil. Plot II, adjacent to the previous one, was on grassland along a fallow. The humus content was only 2.2%, the $CaCO_3$ content 0.9% and the pH 6.7. The surface was turf-bound and the vegetation consisted of several grasses. Six pitfall traps were operated on each of these plots for one week only (April 14th–21st), and five soil samples were analysed on April 14th. The results (multiplied by 2 for the sake of comparability) are given in columns 1 and 2 of tables 1 and 2.

The surface fauna was about 30% more abundant in the plot with the dense weed cover, where humidity, humus and $CaCO_3$ content were much higher than in the grassland. Worms occurred rather frequently at the surface, and were trapped in quite large numbers. The difference between the numbers of animals in the plots was mainly due to the Entomobryidae, the Coleoptera and the Formicidae. Elateridae, however, and Lycosidae, were more numerous in the grassland. Reference should be made to the frequent occurrence of the diplopod indicated as *Orthomorpha coarctata* (Sauss.). On closer examination of the material, one third of the animals in both plots proved to belong to *Chondromorpha xanthotricha* Att. Both species were introduced from southern Asia (communication by Mr. Jeekel). The latter species occurred only in these plots, and may have been introduced recently. *Trigoniulus lumbricinus* (Gerst.) was also introduced from the same regions but, like *O. coaretata* it is more widely distributed in the coastal area of Suriname.

The composition of the soil fauna in the two plots differed only slightly. The greatest differences were found in the Diplopoda, the Coleoptera and the Diptera larvae, which were relatively scarce or even absent in the grassland. This may have been due to the distinct differences in lime and humus contents, as well as to the microclimatic variations caused by the different vegetation.

Dirkshoop

"Dirkshoop," the experimental garden of the Agricultural Experiment Station (323–957 [1])) offered a good opportunity of com-

[1] Coordinates from the 1 : 100.000 map of Suriname sheets 5 and 13. Ed. Centr. Bur. Luchtkartering 1953.

paring the soil fauna of primeval forest, a 20-year-old citrus orchard, and a one-year-old groundnut field. All the plots were sampled in both the rainy season (May-June) and the dry season (October).

The soil in the orchard and in the border zone of the forest consisted of a rather light loamy sand, which changed into a sandy loam farther into the forest. The soil in both forest and orchard was deficient in lime and had about the same humus content (3.4–3.8%). The pH was equal in forest and orchard (3.9), but higher in the groundnut field (4.5). The forest (plot III) reached a height of about 40–50 metres and contained a great variety of species. In the canopy the most noticeable species were *Couratari* sp., *Eschweilera* sp., *Carapa* sp., *Maximiliana maripa* Mart., *Euterpe oleracea* Mart., *Sterculia* sp., *Inga* sp., *Copaifera guianensis* Desf., *Cedrela odorata, Protium* sp., *Virola* sp., *Didymopanax morototoni* Aubl., *Bombax* sp., *Quassia amara* L., *Coccoloba latifolia* Lam. and *Bactris* sp. In the undergrowth the following were prevalent: *Heliconia* sp., *Ravenala guyanensis* (L.C. Rich), *Geonoma* sp., *Ischnosiphon gracilis* (Rudge), *Olyra latifolia* L., *Costus* sp., *Andira* sp., *Cephaëlis violacea* (Aubl.).

In place, a network of gullies with a depth of 10–20 cm and a width of 20—30 cm formed small "islands", hummocks of varying sizes, 50 cm to some metres in diameter (called kawfoetoes = cow's feet). The traps were sunk on these islands, in order to prevent immersion by rainwater; the soil samples were taken partly on the islands, partly in the gullies. However, there only were slight differences, with Coleoptera and Diptera larvae occurring more frequently in the gullies.

The part of the citrus orchard where the samples were taken (plot IV) [Plate Ia] was about twenty years old. The distance between the trees was 7 m. The soil was covered with a dense herbaceous vegetation which was 10–20 cm high in May, at the first sampling, and 20–30 cm in October, at the second sampling. In between, the grass was cut by hand twice. The groundnut field (plot V), an experimental plot for chemical manuring, was harvested some weeks before fauna sampling. It was covered with a weed vegetation of varying density. Traps were placed at random throughout the field; the soil samples were taken partly from the plots with the lowest yields (not fertilized), partly from those with the highest yields, but no difference could be found between these two series as regards soil fauna.

In October the field was ploughed and planted with groundnuts again. Two of the six traps were now sunk in a small fallow part, and four of the ten soil samples were taken there. Only a few groups occurred more frequently in the fallow traps (Entomobryidae, Staphylinidae). *Pheropsophus*, however, a carabid species most frequently trapped in the cultivated field, occurred only rarely in the fallow traps. In both parts, soil samples yielded a very small number of animals.

The results from traps and soil samples from forest, orchard and field are presented in Tables 1 and 2, in columns 3–8 (rainy season) and 26–28 (dry season). The forest was sampled on four sites, the results from which are given separately. The first two sites (columns 3 and 4) were situated within a hundred metres of the border of the forest, the last two (columns 5 and 6) respectively 300 and 600 metres from this border.

Of the surface fauna, it is evident that several groups were less numerous in the inner part than in the border zone or were even absent (Diplopoda, Entomobryidae, Carabidae, Staphylinidae). On the other hand, the numbers of Dermaptera and Isoptera were higher in the inner part. It is possible that the more profuse undergrowth in the border zone may be responsible for this.

On comparison of the surface fauna in the forest with those in the citrus orchard and the groundnut field, big differences are apparent. In the orchard Isopoda, Lycosidae, Entomobryidae, Elateridae and – particularly – Formicidae were much more numerous than in the forest. With the exception of Isopoda and Entomobryidae the same is true of the groundnut field, but here the carabid *Pheropsophus* and the cicindelid *Megacephala* occurred in large numbers and, strange to say, also the milliped *Siphonotus;* a gryllotalpid and the carabid *Taeniolobus* were likewise numerous here. In particular the lycosids, the elaterids and the carabid *Pheropsophus* may be designated as inhabitants of open habitats. In general, the millipeds were less numerous in the cultivated land, especially the groundnut field. The total captures of surface fauna were higher on the cultivated land than in the forest. In the citrus orchard this was due to the very large numbers of ants and springtails; in the groundnut field to the numerous captures of *Pheropsophus, Megacephala* and Scolytidae.

Nothwithstanding the dry weather conditions, the captures in October were surprisingly high. This was especially the case with the Formicidae and *Pheropsophus* in the groundnut field. Only a few species, occurring frequently in May, were absent in October, viz. *Taeniolobus, Brachynus* and *Megacephala.* Of course it is possible that many other species behave in the same way but that their disappearence is masked by the occurrence of other species of the same group.

The soil fauna in the different parts of the forest showed greater uniformity than the surface fauna. The differences in total numbers were mainly due to the variability in the numbers of ants, caused by the presence or absence of an ant's nest in a particular sample. The differences between forest and citrus orchard are only of minor importance, though several groups definitely occurred in higher numbers in the orchard (Isopoda, Japygidae, Entomobryidae), and others in the forest (Diplopoda, Staphylinidae, Campodeidae).

The soil fauna of the groundnut field differed much more from the forest soil fauna. Oligochaeta, Symphyla, Diplopoda, and Staphylinidae were less frequent. Isopoda, Campodeidae, Isoptera did not occur at all in the samples. Only Elateridae occurred more frequently. In contrast to the large numbers of ants trapped in the pitfalls there were only small numbers in the soil samples. The composition of the species of this group is quite different in the two types of sample.

In general, the numbers of animals in the soil samples were somewhat smaller in the dry season than in the rainy season (Formicidae excluded), both in the forest and in the citrus orchard. Oligochaeta disappeared wholly from the upper 5 cm layer. However, canopy and litter layer in the forest, and the dense herbaceous vegetation in the orchard, apparently protected the surface soil sufficiently to maintain a rather numerous animal population. The situation in the groundnut field was quite different; there, the numbers of animals were very low. Of course, the cultivation activities may partly have caused a decline, but in the fallow samples the numbers were low too, and it may therefore be supposed that meteorological influences were the most important cause of the decline.

TAMBAHREDJO

The first station at Tambahredjo (coord. 317–966) was on a shell ridge which was very rich in humus, on the left bank of the River Saramacca.

The lime content in the forest was 27.1%; in the field it varied strongly from place to place. The pH in both parts was 7.1; and humus content was high; 8.5% in the forest and 9.0% in the field.

The forest part of this station (plot VI) [Plate Ib] was rather low; 15–16 m, and consisted mainly of *Hura crepitans* L., *Cecropia* sp., *Spondias mombin* L., *Inga* sp. and *Annona montana* Macfad. In the dense undergrowth, *Guarea guara* (Jacq.), *Vochysia* and very much *Heckeria peltata*, *Bonafousia* sp,. *Cephaëlis violacea* (Aubl.) and *Bromelia* sp. occurred. There was a more or less uninterrupted litter layer on a loose crumbly, humus soil. This forest plot must undoubtedly have been strongly influenced by man. Adjacent to the plot, a one-year-old clearing, scattered with many stumps and fallen trees, had been planted with tomatoes (field 66, owner

Mr. HENDRIK MOELLOED). But in addition to these a profuse vegetation of weeds occurred (plot VII) [Plate Ib].

Both plots were sampled in the rainy season June 11th–24th and in the dry season October 13th–26th. The results are given in columns 9, 10, 29 and 30 of Tables 1 and 2.

The surface fauna in the forest was very numerous. In particular Oligochaeta, Isopoda, Diplopoda, Coleoptera and Formicidae were captured in large numbers. Except for the Oligochaeta, they were caught in nearly all traps, which points to a uniform distribution of these groups. It is evident that land clearance and cultivation measures have had a strong effect on the surface fauna. Only a few earthworms were collected. In the tomato field, the arthropod population had been reduced to about 40%, but several important groups (Isopoda, Diplopoda, Entomobryidae) persisted in rather high densities. "Open field" species did not yet occur.

In the dry season, most groups were definitely less numerous (Oligochaeta, Isopoda, some Diplopoda, Entomobryidae, Staphylinidae), but others remained unchanged or even increased in numbers, e.g. the diplopod *Plusioporus oyapokanus* and the Coleoptera – of these, especially the Scolytidae. It is remarkable that with some groups, the captures decreased in the forest plot but increased in the field, e.g. *Orthomorpha coarctata*, Gryllidae and Formicidae. The specimens of all three groups move on rather rapidly, and it is not impossible that they invaded from the surrounding woods. The locally very dense vegetation may have favoured this invasion. The open field inhabitants, Lycosidae, *Pheropsophus* and Elateridae, were much more numerous than in the rainy season. It is rather likely that these groups had invaded the field from elsewhere since the sampling in June.

The soil fauna of the forest plot outnumbered that of any other plot. The high numbers were caused mainly by Isopoda and Pseudoscorpiones (Chernetes), but other groups were also rather abundant. It may be supposed that the numerous shell fragments provide a suitable habitat for such animals. In the tomato field the numbers of these groups were much lower; the total arthropod population was only about one sixth of the population of the forest plot. The

Oligochaeta were only slightly less numerous than in the forest. Typical field inhabitants, such as Elateridae larvae, were still absent, as was also the case with the imagines of the surface fauna.

In October the soil fauna in the forest was distinctly reduced, but in the field several groups were more numerous than in July: Isopoda, Diplopoda, Japygidae. This may again be attributed to the protective cover of dense weed vegetation. Elateridae, both imagines and larvae, were present now. The soil fauna population of the field during this month was only slightly smaller than that of the forest, and was nearly twice the July population of the same field.

The second station at Tambahredjo consisted of a somewhat marshy wood (plot VIII) and a tomato field nearby (owner Mr. A. G. PRACHT, plot IX), on sandy loam.

The $CaCO_3$ content was low (0.2% in the forest and 1.1% in the field); the humus content high (11.6 and 6.6%, respectively); and the pH about neutral (6.7 in the forest and 7.0 in the field). The tomato field, which had been under cultivation for many years contained many shell fragments in places. Its level was roughly 1 m above that of the forest. The forest, about 20–30 m high, was composed mainly of palm trees *Bactris* sp. and *Maximiliana maripa* Mart., *Annona* sp., *Carapa* sp. and *Hura crepitans* L., with an undergrowth of *Heliconia* sp., *Ischnosiphon asouma*, *Cephaëlis violacea* (Aubl.), *Costus* sp., *Dieffenbachia* sp. and young growth of *Gueria guara* (Jacq.).

The results from traps (June 24th–July 8th) and soil samples are given in columns 11 and 12 of Tables 1 and 2.

In nearly all groups the surface fauna of the forest was less numerous than that of forest plot VI. This may be due to the high water table and the periodic inundations in this plot.

Owing to the great ecological differences between the forest and the tomato field, a comparison of their fauna is rather meaningless. However, the fauna of the tomato field can be compared with that of tomato field VII. In both, the water table lay about the same level and both had a high humus content, but they had been under cultivation for different lengths of time. It is interesting to note that differences were found in the typical field-inhabiting groups, Lycosidae, Gryllotalpidae, *Pheropsophus* and Elateridae, which were more numerous in the old field. The deviations from the October census of field VII were smaller. A second point of difference was the smaller number of Diplopoda in the old field (IX).

The differences between the soil fauna in the forest plots VI and VIII were much more pronounced in the non-insect arthropods, than in the insects. The almost complete absence of the Chernetes in VIII is especially striking. In addition to the periodic inundations of plot VIII mentioned above, the difference may be explained by the fact that the high content of shells in VI presumably provides a suitable habitat for these animals.

In the tomato field the soil fauna was very poorly developed: Oligochaeta, Isopoda and Chernetes were totally absent. Only dipterous larvae occurred frequently and in large numbers. It seems that owing to the unhampered influence of climatic factors and to cultivation, the top layer of the soil has changed into an unfavourable animal habitat. The surface fauna, however, seems able to find sufficient hiding places for maintenance of a moderate density.

SIDOREDJO

This station (coord. 317–964) comprised a low kapoeweri (patch of shrubs about 3 m in length) on the southern slope of a shell ridge (plot X) [Plate IIa], a field of water melons on the top of this ridge (plot XI) [Plate IIa], the same field but on the northern slope of the ridge (plot XIII), and a waste of grasses with some scattered trees at the base of the northern slope (plot XII).

The first two plots had a fine sandy soil with a very high percentage of shells (74.6% $CaCO_3$ in the forest and 65.6% in the field). The humus content was high, 10.8 and 9.6% respectively, and the pH of both plots was 7.3. In the two other plots the soil had a lutum content of 5 and of 8% in the wilderness and in the field; $CaCO_3$ was absent in both plots; the humus content was about 4% and the pH 5.5.

The owner, Mr. J. G. VAN DIJK, told me that the fields had been under cultivation for six years and that the kapoeweri was of the same age. The shrubs of plot X consisted of *Gueria guara* (Jacq.), *Hura crepitans* L., *Bonafousia* sp., *Cephaëlis violacea* (Aubl.), *Cecropia* and *Annona* sp. In this plot, as in plot XI, the "soil" consisted mainly of shells.

The field of water melons was free from any weed growth, and the sandy part had been manured before sowing. In the wilderness (plot XII) small groups of trees and shrubs (*Inga* sp., *Spondias mombin* L., *Cephaëlis violacea* (Aubl.) and *Piper* sp.) were surrounded by a dense herbaceous vegetation. In each of the four plots, three traps were exposed from July 8th till August 5th.

The samples were taken on July 8th, 15th and 21st. The results are given in Tables 1 and 2, columns 13, 14, 15 and 16.

The surface fauna in the shrubs (plot X) was captured in extremely large numbers: Isopoda, several diplopod species – *Rhinocricus monolicornis, Orthoporus flavicornis, Gymnostreptus* sp. – and Entomobrydae were trapped in quantities exceeding those in any of the other sampling plots. The Gastropoda, Blattidae and Coleoptera were also relatively numerous, notwithstanding the poor development of the canopy, which left the surface exposed in places to the direct influence of meteorological factors. Dermaptera, present in all but one of the other forest plots, were absent here. On the other hand, this was the only wood plot where the "open field species" *Pheropsophus* was captured – a fact which shows the rather intermediate position of the plot. In the melon field almost all groups were reduced in number, and the composition of the surface fauna agrees quite well with that of the Tambahredjo fields. Of the "open field species" only *Pheropsophus* occurred in great abundance. Remarkably enough, both Oligochaeta and Gastropoda were trapped in larger numbers than in the kapoeweri plot. In the waste (plot XII) all main groups present in the shrub plot were recorded, but their numbers were much smaller. Somewhat smaller in general were the numbers captured in the melon field on sand, where only the figures for *Orthomorpha* were unexpectedly high. It is interesting to note that the surface fauna in the two adjoining melon fields of this station agree rather closely, notwithstanding the great difference in soil. The main differences were found in the case of the Oligochaeta, Gastropoda and some diplopod species. This may suggest that the surface fauna moving around in the field makes no distinction between the different soil properties. It is not certain, however, that they can complete their life cycle equally well on both soil types.

The soil fauna in the kapoeweri here and in forest plot VI at Tambahredjo showed rather great similarity. In the kapoeweri the main part was again formed by Isopoda and Chernetes, but their numbers were lower. In the adjoining field, on the same soil type, most groups were less abundant or even nearly absent (Isopoda), but some groups maintained themselves (Oligochaeta, Japygidae) or increased considerably (Chernetes). In general the soil fauna of this field resembled that of the one-year-old clearing with tomatoes at Tambahredjo, notwithstanding its longer time of cultivation. This would suggest a rather stable soil fauna on the ridge soils, which are rich in humus and shells, in contrast to those soils poor in shells (plot IX), where the soil fauna became very poor after about five years of cultivation. In both sand plots of this station the Chernetes, so abundant in the shell-containing soils, were totally absent, but there were rather large numbers of Coleoptera larvae and Diptera larvae. This may be connected with the waterlogged situation which arises after heavy rains.

The soil fauna in the sandy soils differed much more from that in the adjoining soils rich in shells and humus (plots X and XI) than did the surface fauna on these soils. The soil conditions apparently influence the soil-inhabiting animals much more than they do the surface animals.

La Poulle

This station (coord. 326–956, owner Mr. Ori), south of the Hamburg-Groningen road near kilometre stone 37, was chosen for comparison of the fauna in a pasture, in shrub (kapoeweri) and in a field of water melons.

The soil had a low lutum content (2—5%) and was poor in humus (2.6–3.9%). Only in the kapoeweri was there some lime present (1.1% $CaCO_3$), and the pH was 7.1 In the two other plots the pH was 4.2.

Plot XIV was overgrown with a dense stand of *Ravenala* sp. about three metres high. Adjacent to it was plot XVI, a field covered with weeds and grasses at the start of sampling, on August 5th, but cleaned and planted with water melons at the end (August 19th). This will certainly have influenced both trapping and soil-sample results. The pasture, plot XV, adjoining the above field, had been covered with a dense mat of grass for the last five years. The soil of all stations consisted of fine sand poor in humus.

The results are given in columns 17, 18, and 19 of Tables 1 and 2.

The surface fauna in the shrub plot, as compared with most other forest plots, was poorly developed. Hardly any Oligochaeta, Isopoda or Diplopoda were captured. Only the Dermaptera were very numerous. This poor development of the fauna was probably due to the uniform composition of the vegetation and the former agricultural use of the land. Both pasture and field differed mainly from the shrub in the absence of Dermaptera, the scarcity of diplopods, and the presence of open field species, viz. Lycosidae, Gryllotalpidae, *Taeniolobus, Pheropsophus* and Elateridae. Compared with the other fields, the scarcity of Isopoda and Diplopoda (except *Siphonotus*) is evident. The difference between melon field and grassland is restricted mainly to the diplopod *Siphonotus* and the Entomobryidae, which occurred in much larger numbers in the melon field, and to the Formicidae, which were more numerous in the grassland.

The soil fauna in the shrub plot was most similar to that in the primeval forest plots on sand (III). It differed from these plots in its small number of Oligochaeta and its rather large numbers of the diplopod *Poratia.*

In the melon field small numbers of Diplopoda, Campodeidae and Formicidae were caught, but large numbers of Oligochaeta, Isopoda and Coleoptera, resulting in a higher total number of animals in this plot than in the shrub plot. It must be noted that the rather large numbers of Oligochaeta and Isopoda are due to a few samples only. In the pasture the non-insect arthropods were very scantily represented; Apterygota were absent. Most other insect groups, however, were more numerous there than in the forest.

VANK-KOLONIE

The plots on this station (coord. 324–956), a kapoeweri and a pasture, had a fine sandy soil.

Lime was absent and the humus content in both plots was 3.2%. The pH was 4.1 in the kapoeweri as against 3.4 in the pasture. The kapoeweri (plot XVII) [Plate IIb] was provided with drains, and had formerly been used as agricultural land. The shrub vegetation was 4–5 m high, and was composed of a variety of species, providing a rather dense canopy. The other plot, adjoining the kapoeweri plot, was a pasture (plot XVIII) [Plate IIb], and had been laid out five years before (owner Mr. J. A. GRAANOOGST). The pitfall traps were operated for one week only, from August 19th to 26th. One series of five soil samples was taken in the shrub plot, and two series in the pasture plot. In the pasture, trapping was repeated from October 13th to 26th and soil samples were taken on October 13th and 20th.

The results are presented in columns 20, 21 and 31 of Tables 1 and 2.

Apart from small differences, the surface fauna of the shrub plot closely resembled that of the shrub plot of La Poulle, also an old agricultural field. Oligochaeta, Isopoda and Diplopoda were poorly represented, but Dermaptera were abundant. A point of difference is the very large numbers of Formicidae in this plot. In the pasture the surface fauna bore a rather close resemblance to that of the pasture plot at La Poulle. Both these pasture plots were deficient in Diplopoda, but most insect groups were well represented. Elateridae, in particular, were very numerous.

In the dry season the captures were essentially similar. As against groups that were reduced in number (Homoptera, Coleoptera), others were increased (Araneida, *Pheropsophus*, Formicidae).

The soil fauna of the two plots also resembled those of the corresponding plots at the La Poulle station, except for the rather large numbers of Isopoda, Japygidae and some insect groups in the forest at Vank-kolonie, and the frequent occurrence of Oligochaeta and the scarcity of Formicidae in the pasture.

The October samples contained no Oligochaeta, and the Diptera larvae, rather numerous in the rainy season, were also nearly absent.

Compared with the forest, the pasture was very poor in non-insect arthropods. Some of the insect groups were more numerous than in the forest (Elateridae, and Diptera larvae); others were less abundant or wholly absent (Campodeidae, Japygidae, Thysanoptera, Staphylinidae and Formicidae).

It is striking that, in the pasture plots of this and of the previous station, Diplopoda were very scarce or even absent. It seems probable that this type of cultivated land offers bad conditions for this group of animals.

Boven Sarakreek

During September a visit was made to the primeval forest on the right bank of the Sarakreek, about 40 km upstream from where it joins the River Surinam.

Unfortunately, it is not possible to give an account of the tree species. The forest was composed of three stories; an upper, discontinuous one reaching about 40–50 m; a second, more continuous one, reaching 25 m; and a third story 3–10 m high. In the lowest story many species of palm trees occurred. The herbaceous layer was very scanty except in spots which received light.

The laterite soils of this forest had a slight to medium lutum content (6–20%) and were poor in humus (2–6%) $CaCO_3$ was absent or almost absent.

The forest fauna was studied on two plots. The first (plot XX) was on the slopes of Maripaheuvel, a hill about 110 m high, 5 km east of Poeroe man Kemisa, the landingplace on the Sarakreek. The second forest plot (XXI) was near Poeroe man Kemisa, adjoining a field which had been cleared the previous year and was planted mainly with rice, cassava, corn and sugar cane. This field was also studied (plot XXII) [Plate IIIa]. Many felled trees were still present, between which the different crops had been sown in a very irregular pattern. A second field plot (XXIII) [Plate IIIb], cleared a year earlier and adjacent to the other one, bore some crops left over from the previous season (cassava, banana, sugar cane); but for the rest it was covered with a dense weed vegetation.

The soil of these fields had a rather high humus content of 5.5% and the pH was 4.5 and 5.3 respectively.

In each field six pitfall traps were used for a week, on two sites successively. It was not possible to collect the soil fauna from the samples during the stay in the forest, and so one series of five samples was taken in each of the plots immediately before departure. As the homeward journey took two days, the samples were treated not earlier than three days after being taken, which may have had some influence on the results.

The results are given in Tables 1 and 2, in columns 22 to 25 inclusive.

The first striking feature of the surface fauna of these plots is the absence of Diplopoda. In the forest plots some individuals were captured, but in the field they were completely lacking. Gastropoda were not captured either and Oligochaeta were taken only in very small numbers. The total number of non-insect arthropods was lower than in any of the other plots studied.

In contrast to this, several insect groups were captured in relatively large numbers, viz.: Entomobryidae, Blattidae, Gryllidae and Isoptera. The last group was taken very irregularly.

In the fields, Isoptera and Dermaptera were captured in very small numbers. Lycosidae, Acridiidae, *Pherophosphus*, Elateridae and Formicidae occurred in larger numbers than in the forest. The difference in fauna between the two clearings was of minor importance.

The soil fauna was also rather poorly developed in the forest. This was especially the case with most insect groups. It must be admitted that the three days which elapsed between collecting and handling the samples may have been of some influence. On occasions, however, where storage of part of the samples could not be avoided, this influence was only of minor importance.

The very small numbers of the different groups point to a low density of these groups. Other groups, however, were collected in rather large numbers, viz. Campodeidae, Japygidae, Isoptera and Formicidae, of which the Isoptera, however, occurred in two samples only. In the other arthropod groups the Isopoda were very scarce, but Symphyla, Diplopoda and Chilopoda were present in numbers comparable to the other forest plots on sandy soil.

Both cultivated areas were extremely poor in fauna, which shows the detrimental influence of land clearance on the fauna in these soils. Diplopoda and Chilopoda did not occur at all, and the groups of insects, found in abundance in the forest samples, were here reduced to a few specimens only. The small difference between the two and one-year-old clearings may not be considered fundamental, with this small number of samples.

4. Discussion

a. Comparison of the fauna in the different plots

Surface fauna

Comparison of pitfall captures was possible only to a limited degree. Within the stations the traps were operated simultaneously, and so the captures on different plots within a station may be compared on this basis. Comparison of captures at different stations gives rise to more objections. Though all captures are related to a 14-day period, the periods were at different dates, and this may invalidate the comparability. It is evident that this hindrance is most serious under deviating meteorological and climatic conditions. The main part of our investigation was carried out during the rainy season, and at this time the meteorological conditions were rather stable, in any case much more stable than in a temperate climate.

Since it was impossible to capture the fauna simultaneously in all stations, only a rough comparison between these stations is justified.

The total number of animals captured in the traps, as indicated at the bottom of Table 2, varies widely from plot to plot. In the forest plots these great differences are mainly caused by the great differences in the numbers of Formicidae and Scolytidae. If these groups are excluded the numbers of the remaining arthropods give a clearer picture. The same holds good for *Pheropsophus* sp. in the cultivated fields.

In the forest plots the highest numbers were captured in the "kapoeweri" on the shell ridges, rich in humus (plots VI and X). This is still true even after exclusion of the extremely high number of isopods in X. These plots are followed by the plot in the border zone of the primeval forest (III, col. 3). In the latter the captures during the dry season were also rather high (D III). The lowest captures were made in the inner part of the primeval forest (III, col. 6) and in the Tambahredjo kapoeweri during the dry season (D VI).

The captures in all the other forest plots vary between 400 and 500 specimens. Though these total numbers are anything but an ideal basis for comparison, the range from rich to poor animal communities is confirmed by inspection and comparison of the whole columns of the plots concerned in Table 1. It appears that the surface fauna is best developed in the secondary forest on shell ridges. Oligochaeta, Gastropoda and Isopoda, and several species of Diplopoda (*Orthomorpha, Rhinocricus* and *Orthoporus*), clearly show their richest development on these soils.

Within the primeval forest the surface fauna changes from rich in the border zone to poor in the inner part. This rich fauna in the border zone suffers much less from drought than the even richer fauna in the shrubs on shell ridges. In the dry season their populations are reduced to 80% and 37% respectively. Notwithstanding the rather small variations in total numbers of Arthropoda there are evident differences in the composition of the surface fauna of the remaining forest plots. In the shrub vegetations on sand deficient in humus, La Poulle (XIV) and Vank (XVII), the Diplopoda are poorly developed, but this is numerically compensated by the abundance of Dermaptera. Still smaller is the number of

Diplopoda in the inland forest (XX and XXI), but here several insect groups make up for this shortage. In the marshy wood on sand rich in humus (VIII), and in the shrub vegetation on loamy sand (XII), the composition of the surface fauna is rather "harmonious."

With respect to the Scolytidae, which, like the Formicidae, were excluded from this comparison, it must be noted that the species as identified by Dr. K. SCHEDL feed mainly on trree fruits. Apparently they are attracted to the alcohol traps. Their numbers differ greatly from plot to plot irrespective of the nature of the forest, but this may possibly be due to local abundance of fruit. Hence the largest number was captured in one of the inland forest plots (XX), whereas in the other plot of the same station (XXI) the capture was the lowest of all the plots but one.

The numbers of Formicidae also vary greatly. The smallest numbers were captured in the primeval forest (III, XXI), the largest numbers in two of the secondary forest plots, one on shell ridge soil (VI), the other on sand (XVII). In the dry season the numbers increased in the primeval forest (III) but decreased in the secondary forest (VI).

In the field plots the total numbers differ less than in the forest plots. In contrast to the forest, the total numbers of surface fauna are not larger in the fields on shell ridges, but inspection of the columns reveals that many more groups are present there than in the fields on sand, though in small quantities. The greatest numbers of animals were captured in the tomato field on sand (IX) – mainly owing to the large numbers of small coleoptera – and in the pasture of the Vank station (XVIII), owing to the abundance of Elateridae.

Rather high captures were also made in the melon field on sand (XVI) and in the citrus orchard (IV). Lowest numbers were present in the pasture field of the La Poulle station (XV). In the other fields the numbers varied roughly from 300 to 400, and so the total numbers of field surface fauna generally are only slightly less than in the forest. But the composition is quite different. The numbers of saprophagous species are severely reduced (Isopoda, Diplopoda, Dermaptera), but "open field species" (Lycosidae, Elateridae and the Carabidae, *Pheropsophus* and *Taeniolobus*) take their place.

It is remarkable that Scolytidae were also captured in the cultivated land, sometimes even in large numbers. It must be assumed that they were attracted to the pitfall traps, possibly from long distances away, by evaporation of some alcohol. In general, numbers are largest in those plots which adjoin the forest.

Formicidae were extremely numerous in the groundnut field, and in the citrus orchard during the dry season (D IV, D V), but they were also captured in great numbers in the rainy season.

Pheropsophus occurred in all fields, but in widely differing numbers. It is not clear to what factors these numbers may be related. The small number in the recently cleared field (VII) in June, and the much larger numbers in the same field (D VII) in October, point to a rapid immigration of the species.

Soil fauna

Comparison of the soil fauna in the different stations is less difficult than comparison of the surface fauna. These results are much less dependent on the circumstances in which the samples were taken. The great and varying number of Formicidae makes it desirable to exclude them from the total number here too.

The soil fauna in the different forest plots shows much more uniformity than the surface fauna. The large total number of arthropods in the forests on shell ridges, rich in humus (VI, D VI and X), is caused by the extremely large numbers of Isopoda and Chernetes. High densities were also found in the kapoeweri on sand (Vank, XVII) and in one of the Sarakreek plots (primeval forest on sand (XX)).

With the exception of the fauna in this latter plot, the soil fauna was less numerous in all primeval forest samples than in samples from secondary forest. The numbers ranged from 200 to 300 and from 300 to 450 per 10 dm^2 respectively.

In the field plots the total arthropod number exceeds 250 in only four cases. In three of these plots (XI, XIII and D VII) the high number is due to one or two species only. The fourth plot, melon field on sand (XVI), really harbours a relatively rich soil fauna. In all other field plots the total number ranges from 150 to 250 per 10 dm^2 with the exception of the two clearings in the inland forest (XXII and XXIII) and the groundnut field in the dry season (D V), where the total numbers are respectively 42, 82 and 51 per 10 dm^2. From this it is evident that, generally speaking, the soil fauna is severely reduced by cultivation. In pastures these reductions are relatively less severe than in arable fields.

b. The fauna in the fields and in the adjacent woodlands

The preceding section, 4a, shows that in general both the surface fauna and the soil fauna are less abundant in the fields than in the forest if Formicidae, Scolytidae and *Pheropsophus* are excluded from the surface fauna and the Formicidae from the soil fauna. If these groups are included, the lesser abundance in the fields remains valid as regards the soil fauna, but the total surface fauna appears more numerous in the fields, mainly owing to the large numbers of *Pheropsophus* caught only in the fields.

For a more detailed comparison, the numbers of animals in the fields can be compared with those in the adjacent woodlands. In Table 3 the numbers of arthropods in the fields are given as per-

Table 3 Arthropod numbers in different fields, in percents of those of the adjacent woodlands.	Surface fauna			Soil fauna	
	Arthropoda excl. Formicidae Scolytidae, *Pheropsophus*	Formicidae	Scolytidae	Arthropoda excl. Formicidae	Formicidae
IV Citrus orchard on sand	76	860	16	83	14
V Ground-nut field on sand	70	252	150	57	4
VII Tomato field on shell ridge	47	24	42	18	13
XI Melon field on shell ridge	16	140	219	90	6
XIII Melon field on sand	84	114	118	108	37
XV Pasture on sand	67	396	57	70	336
XVI Melon field on sand	151	194	16	131	33
XVIII Pasture on sand	152	73	78	48	8
XXII Agricultural field on sand 1st year	77	495	69	17	—
XXIII Agricultural field on sand 2nd year	61	623	43	33	2
D IV Citrus orchard (dry season)	57	585	13	86	325
D V Ground-nut field (dry season)	64	942	6	15	12
D VII Tomato field (dry season)	127	460	19	90	14

centages of those in the adjacent forest. It appears that in two fields (VII, XI) the surface arthropods were less than 50% of those in the forest. Both fields are situated on shell ridges, and the adjacent forests are extremely rich in arthropods. It is worth mentioning that in the dry season the surface arthropods in the tomato field (D VII) were more abundant than in the forest. In two fields only were the surface arthropods more numerous than in the forest (XVI, XVIII), owing in the latter case, to the great abundance of one species of Elateridae. In all other instances the arthropod density is about 20–40% less than in the forest. This short series of observations gives no indication that the density of surface arthropods is very different on arable land, pasture or orchard.

With the exception of two cases the epiedaphic Formicidae were much more numerous in fields. The small relative abundance in the two cases mentioned (VII, XVIII) was caused by the exceptionally high numbers in the adjacent forest.

As may be expected, the Scolytidae were less abundant in the fields. There were three exceptions, however, of which that of the groundnut field might be explained by clearing and burning in an adjacent wood plot. This was probably also the case in the forest near the two melon fields, these being, in fact, one field with different soil types.

In four fields the soil fauna appears to be less than 50% of that in the adjacent woodland. Two of these fields were reclaimed recently (VII, XXII). In the tomato field on shell ridge the second sampling in the dry season (D VII) revealed an only slightly lower density as compared with the forest, suggesting a rapid increase of the soil arthropods after reclamation. In the two-years-old reclamation site in the inland forest (XXIII) the soil arthropods are also more abundant than in the one-year-old reclamation site, but they remain numerically far behind the forest population.

The groundnut field shows a very severe reduction during the dry season, probably caused by meteorological conditions (see p. 14).

Slightly less abundance of the soil arthropods was found in the citrus orchard (IV), but also in the melon field on shell ridge (XI), whereas the population in both melon fields on sand (XII, XVI) is greater than in the adjacent forest. This may perhaps be attributed to the manuring of these plots.

In contrast to the surface-dwelling ants the soil-inhabiting Formicidae are generally much less numerous than in the adjoining forest. However, in two cases they exceeded the forest population by 100% (XV, D IV). In the citrus orchard in the dry season this may be caused by the accidentally small numbers of ants taken in the forest. The soil-living ants are extremely scarce in both reclamation sites in the inland forest (XXII and XXIII).

c. DISTRIBUTION OF FAUNA GROUPS IN FORESTS AND CULTIVATED LAND

If, from the foregoing an attempt is made to judge what groups are real forest inhabitants that suffer a more or less severe reduction by clearance and subsequent cultivation of the land, and what groups are apparently favoured by these measures and have been called "open field inhabitants", we arrive at the following list for the SURFACE FAUNA.

Forest inhabitants

Isopoda	Although results were often not conclusive in stations where small numbers were captured, the numbers were much larger in the forest in all stations where this group was abundantly present.
Diplopoda	Only one species, *Siphonotus* spec., was captured in larger numbers in the fields.
Blattidae	Were always more abundant in the forest, though the difference was small.
Dermaptera	Occurred in the field on only a few occasions.
Isoptera	The numbers captured were small but always larger than in the field.
Staphylinidae	Although their numbers could be rather large in the fields, they were always smaller than in the adjacent forest.
Scolytidae	A bigger difference might be expected between the numbers of these tree inhabitants in forest and in field. Their great olfactory sense and great mobility may be responsible for the rather large numbers in the field.
Brachynus sp.	Restricted to some stations only, but here nearly absent from the field.

Open field inhabitants

Lycosidae	Just as in the temperate zone, this family was much more abundant in cultivated fields and pastures than in forests.
Acridiidae	The small numbers collected originated mainly from the fields.
Gryllotalpidae	Rarely occurred in the forests but were present in nearly all field plots.
Taeniolobus sp.	This large species was exclusively captured in fields and pastures.
Pheropsophus sp.	Was captured in nearly all field plots, and sometimes even in very large numbers. It occurred in one shrub plot only, in open spots.
Elateridae	This family also occurred in rather large numbers in all field plots, whereas it was captured in only small numbers in some forest plots.
Formicidae	Although ants were collected in both forest and field plots, the numbers in the latter were generally much greater.

Gastropoda, Chernetes, Chilopoda, Lepidoptera larvae, Coleoptera larvae and Diptera were in about equal quantities in forest and field plots. Their numbers were small, however.

In the remaining groups the results were inconclusive. In one station the group prevailed in the forest, in another in the field. The groups concerned are Oligochaeta, Araneida, Entomobryidae, Gryllidae, Heteroptera, Homoptera and Coleoptera imagines.

In the SOIL FAUNA the following groups were classified in the same categories:

Forest inhabitants

Gastropoda	Were present only in some stations, but here the differences were apparent.
Isopoda	Notwithstanding some exceptions it is clear that this group was more numerous in the forest samples than in the field samples.
Diplopoda	Great differences were found between forest and field samples.
Chilopoda	In both categories the numbers were small, but were generally higher in the forest samples.
Symphyla	In general the differences were great, but some exceptions occurred.
Araneida	Although the differences were not great, the numbers captured from the field samples were constantly smaller than those from the forest samples.
Campodeidae	Here the differences in numbers were rather large.
Entomobryidae, Isoptera and Scolytidae	Were present only in small numbers in the samples, however it is very probable that they prefer forests.
Staphylinidae	Were clearly more abundant in the forest samples.
Formicidae	Remarkably enough, the soil-inhabiting ants were generally more numerous in the forest samples than in the field samples, whereas the opposite was observed in the case of the surface-dwelling ants.

Open field inhabitants

Elateridae	Both larvae and imagines belonged to this category. In the forest samples they occurred only sporadically.
Diptera larvae	Were generally also more abundant in field samples than in forest samples.

In all other groups the results were inconclusive: Oligochaeta, Chernetes, Japygidae, Thysanoptera, Psocoptera, Heteroptera, Homoptera and Coleoptera.

From the foregoing it may be seen that the surface fauna of the forest as well as of the field can be divided into a number of characteristic groups. In the soil fauna a great number of groups generally occur more abundantly in the forest, whereas only two groups are more numerous in the field. These two groups are larvae of Elateridae and Diptera, the adults of which can easily reach the fields by flight and deposit their eggs there.

It seems justified to say that the soil fauna in the fields is markedly impoverished and that not one group of real soil inhabitants is better developed there than in the forest. The surface fauna in the fields, however, includes several groups which are more numerous than in the forest or which even occur exclusively there. They are adapted to open field conditions, and apparently reach the clearings within a few months (Tambahredjo VII, D VII). This difference between surface fauna and soil fauna is clearly demonstrated by the Formicidae, of which the soil-inhabiting species are more abundant in the forest and the surface-dwelling species in the field.

d. Distribution of millipedes in forests and cultivated land

The Diplopoda belong to the main groups of the fauna in the forests and, to a much lesser degree, in the fields. Though their numbers are exceeded by those of many other groups, this is certainly not the case with their biomass. Among the smaller species, ranging from 5 to 15 mm, *Glomeridesmus*, *Onciurosoma* and *Poratia* were caught nearly exclusively in soil samples, *Siphonotus* chiefly in pitfall traps, and *Stemmiulus* in both. The medium-sized species, ranging from 2 to 4 cm, were caught mainly in traps, but they were also present in soil samples, especially the younger individuals. All other species (4–10 cm) were trapped exclusively in pitfalls, and occurred only incidentally in soil samples.

From the distribution given in Table 4 it appears that three of the five small species occurred entirely in forests, viz. *Glomeridesmus*, *Onciurosoma* and *Stemmiulus*. The first two species were caught only in small numbers, on four of the forest plots only. *Stemmiulus*, however, was caught in rather large numbers both in soil samples and in pitfall traps, and occurred in all but one of the forest plots. So it seems evident that this species is not accustomed to field conditions. *Poratia* was also present in all but one of the forest plots, but likewise occurred in a great number of field plots. Since it was not taken in pitfall traps, its surface activity is appa-

Table 4
Distribution of Millipedes in forests and cultivated fields

Species	Total number taken in: forests	Total number taken in: fields	Forest plots: III	VI	VIII	X	XII	XIV	XVII	XX	XXI	Field plots: IV	V	VII	IX	XI	XII	XV	XVI	XVIII	XXII	XXIII	I/II
Glomeridesmus	18	—	+	+				+	+														
Onciurosoma	9	—	+	+			+	+															
Stemmiulus	108	—	+	+	+	+		+	+	+	+												
Poratia digitata (Por.)?	99	50	+	+	+		+	+	+	+	+	+		+	+		+	+	+				+
Siphonotus	39	128	+		+	+	+	+				+	+	+	+	+	+	+	+				+
Epitrigoniulus	33	—	+			+																	
Nanostreptus grayi (Bröl.)	47	—			+																		
Rhinocricus monolicornis (Por.)	301	121	+	+	+	+	+					+	+	+	+	+	+			+			+
Orthoporus flavicornis (Por.)	107	37	+	+	+	+	+	+	+			+	+	+	+	+	+	+	+	+			
Plusioporus oyapokanus (Att.)	196	38	+	+		+		+				+	+	+						+			
Gymnostreptus	863	109	+	+	+	+	+	+	+			+	+	+		+	+						
Orthomorpha coarctata (Sauss.)	151	382		+	+	+	+						+	+	+	+	+						+
Chondromorpha xanthotricha (Att.)	—	77		+	+	+	+																+
Trigoniulus lumbricinus (Gerst.)	2	4				+																	+

rently small. Its occurrence in the field plots, though less frequent and less abundant than in the forest plots, suggests that this species may maintain itself in the field. In several arable fields, however, the species did not occur at all (V, IX, XXII, XXIII).

Siphonotus, with a great surface activity, occurred more frequently and more abundantly in the field plots than in the forests. This diplopod species seems to be the one best adapted to field conditions.

Among the bigger species, *Epitrogoniulus* and *Nanostreptus* were only caught in the forest, but in not more than two plots and one plot, respectively. Data are too few to permit the conclusion that these species are exclusively forest inhabitants.

Rhinocricus, *Orthoporus*, *Plusioporus* and *Gymnostreptus* occur rather frequently in both forests and fields. All these species, however, are much more abundant in the forest plots than in the field plots. It is to be noted that none of them occurred in the inland forest. It is rather difficult to judge whether the population of these big diplopods maintains itself in the field in a moderate density or whether the animals merely ramble about in the fields, occasionally returning to the forest. The fact that young specimens of the species *Rhinocricus* and *Orthoporus* were present only in the soil samples from the recently reclaimed fields, and were absent in the samples from the older fields, suggests that the standing population maintains itself only for a short time. Thereafter the animals present in the field are ramblers, and do not propagate there.

The three remaining species have all been introduced into Suriname from Southern Asia. None of them was found in the primeval forest. *Orthomorpha* and *Trigoniulus* were taken on different stations in the coastal region, though the first occurred in many more than the second. *Chondromorpha* has probably been introduced recently, as it was only taken in the experimental garden at Paramaribo. All these introduced species were more numerous in the fields than in the forest plots.

e. Distribution of ants in forests and cultivated land

Study of the ants collected, which was admirably performed by Kempf (1962), yielded 171 species, of which at least 6 were new to science. This means that about 1/30 of the species of the world ant fauna were collected in the present investigation. Of the 126 species identified, 37 were Ponerinae, 10 Dorylinae, 2 Pseudomyrmicinae, 55 Myrmicinae, 6 Dolichoderinae and 16 Formicinae. As against 114 species in the woodlands, there were 70 species in the fields. The difference between these numbers was mainly caused by the Ponerinae, of which 34 species occurred in the forests and 14 in the fields, and by the Myrmicinae, with 54 species in forests and 31 in fields. In the other subfamilies the numbers in forests and fields were about even.

The qualitative richness of the ant fauna in forests is also demonstrated by the fact that 64 species were taken exclusively in the forests as against 20 species exclusively in cultivated areas. These 64 "forest" species, however, included several mentioned by BÜNZLI (1935) as found in coffee plantations, e.g. *Acropyga paramaribensis*, which is described by him as the most frequent endoedaphic ant in Surinam coffee plantations. Hence the designation "forest species" has not to be interpreted too strictly.

The remaining species were taken both in forests and in fields. In Table 5 the more frequent species are presented.

The first group, five Ponerinae and five Myrmicinae, occurs decidedly more frequently in forests than in fields. The occurrence of five of these species in the citrus orchard (IV) points to the transitional position of this plot between forests and fields. In plot XII, with a dense grass vegetation and some scattered groups of trees, only two of the species occurred.

The second group is about evenly distributed amongst forests and fields. The small *Solenopsis pygmaea* was taken almost exclusively in the soil samples. Notwithstanding the very large numbers of the Doryline *Labidus predator* it was only found in three forest plots and three field plots. Two of these forest plots were adjacent to two of the field plots. The large numbers are caused by the predatory and migratory activities of this army ant. Another army ant, *Labidus coecus*, occurred much more frequently in the forests as well as in the fields, but their total number was much lower. *Ectatomma quadridens*, *Solenopsis geminata* and *Brachymyrmex patagonicus* were caught in the largest numbers. They occurred

Table 5

Distribution of the most frequent Ant species in forest and cultivated field

	Total number taken	Forest plots									Field plots											
		III	VI	VIII	X	XII	XIV	XVII	XX	XXI	IV	V	VII	IX	XI	XIII	XV	XVI	XVIII	XXII	XXIII	I/II
Gnamptogenys tortulosa (Smith)	21	+	+	+	+		+	+												+		+
Gnamptogenys horni (San.)	61	+	+		+	+	+	+	+		+											
Mesoponera constricta (Mayr)	56	+	+	+	+		+	+	+	+	+											+
Typhomyrmex pusillus Em.	56	+	+		+	+	+			+		+		+								
Pachycondyla harpax (Fabr.)	55	+	+				+	+	+		+						+	+				
Strumygenys denticulata Mayr	58	+		+	+		+	+	+	+									+			
Strumygenys perparva Brown	98	+		+			+		+													
Octostruma balzani (Em.)	55	+	+	+	+		+				+								+			
Rogeria curvipubens Em.	72		+	+	+		+				+		+									
Crematogaster brasiliensis Mayr	99	+	+		+			+	+	+									+	+	+	
Solenopsis pygmaea For.	200	+	+	+	+	+	+				+		+	+		+						+
Wassmannia auropunctata (Roger)	430	+	+				+		+	+	+	+				+			+		+	
Labidus praedator (Smith)	2154		+			+		+				+				+			+			
Labidus coecus (Latr.)	412	+	+	+		+		+		+		+	+		+	+	+	+	+	+		
Ectatomma quadridens (Fabr.)	2629		+	+	+	+	+	+			+	+	+	+	+	+	+	+	+	+	+	+
Solenopsis geminata (Fabr.)	950	+	+		+		+	+			+	+	+	+	+		+	+	+		+	+
Brachymyrmex patagonicus Mayr	760	+	+		+	+					+	+	+	+	+	+	+	+	+	+	+	+
Conomyrma brunnea (For.)	37	+	+										+		+	+	+	+	+			
Odontomachus haematodus (L.)	44	+					+	+			+	+		+			+	+	+			
Cyphomyrmex rimosus (Spin.)	84	+	+		+		+				+		+	+	+				+	+		+
Solenopsis saevissima (Smith)	220	+	+									+	+		+		+	+		+	+	
Pheidole fallax Mayr	174							+				+	+			+	+	+	+	+	+	
Brachymyrmex fiebrigi For.	373					+		+			+			+		+	+	+				+

rather frequently in the forests. Two of the species occurred in any one of the field plots and one was absent in only two plots. These three species, together forming about one third of the total collection, apparently have the widest ecological range of all species found. Nevertheless it must be remarked that not one of them was found in the inland forest (XX and XXI), and that *Ectatomma quadridens* was also absent in the primary forest at Dirkshoop (III).

The last group contains species that occur infrequently in the woodlands but frequently in the fields. Possibly they are more adapted to open field conditions. Their numbers were much smaller than those of the preceding species. This suggests that the species which developed in the largest numbers were not those most adapted to field conditions, but those with the widest ecological amplitude.

The complete list of species can be found in KEMPF's paper to which reference may also be made for more details.

f. COMPARISON OF SOIL ARTHROPODS IN TROPICAL AND TEMPERATE ZONES

Several authors, who have studied the fauna of tropical soils state that this fauna is less abundant than in temperate zones (SALT 1952, DELAMARE DEBOUTTEVILLE 1951, GOODNIGHT & GOODNIGHT 1956, SCHALLER 1961). MEYER & MALDAGUE (1957) found the density of the mesofauna in the Congo to be comparable with the density in temperate zones, but stressed the fact that the litter production is about three or four times as high in the Congo. Nevertheless there is no accumulation of litter, and they conclude that this must be attributed to the greater activity of the organisms at the constantly higher temperatures throughout the whole year. NYE (1961) mentions, from moist tropical forest in Ghana, a litter production of about 10,620 kg/ha, roughly two thirds of which consisted of leaves. If no litter accumulation occurs, this means a yearly decomposition of about 7,000 kg/ha of leaf litter.

The author's observations of the disappearance of forest leaf litter in oak woods in the Netherlands yielded values of 300—350 gr/m^2 or 3,000–3,500 kg/ha, and other investigations in the temperate zone have resulted in amounts of the same magnitude (KITTREDGE 1948). So it seems that the rate of decomposition of organic debris in the tropics is greater than in temperate regions, but that the soil biota is numerically less.

However, quantitative evaluation of the soil biota, in particular of the soil fauna in the tropical and temperate zones, is a knotty problem. First of all the techniques applied have to be comparable, and it is safe to say that no two investigators practice wholly comparable methods. Hence, strictly speaking, only the results obtained by one author, based on the same techniques, can be compared with each other. Furthermore, it seems advisable to consider the microarthropods (Acari and Collembola) separately, since the huge numbers of these groups completely mask the numbers of the other arthropods. For the same reason the Formicidae have to be excluded.

In Table 6 the average numbers of macroarthropods per m^2 in this survey are presented in comparison with those from two surveys carried out in oak forests and in arable fields on sand in the Netherlands. The same sampling tools and apparatuses were used in all these studies. It seems that the average numbers of macroarthropods, both in the forests and in the fields, are larger in Suriname than in the Netherlands. The data from Denmark, Trinidad and Panama – where, however, different techniques were used – also suggest a greater density of the macroarthropods in tropical forest soils. SALT (1952), studying pastures in east Africa, found larger numbers of macroarthropods (probably owing to his technique), but they were about the same as those found in his survey in English pastures, where the same technique was used.

TABLE 6 Soil arthropod populations in tropical and temperate regions	MACROARTHROPODA (excl. Formicidae) average number per m^2 and range		MICROARTHROPODA (Acari and Collembola) average number per dm^2 and range	
	forests	fields	forests	fields
Suriname	4264 (1970–10410)	2491 (400–5040)	450 (137–812)	355 (90–851)
Netherlands	1938 (1485–2445)	1406 (785–2500)	705 (260–810)	121 (60–210)
Denmark (BORNEBUSCH 1930)	1690 (700–2900)			
Trinidad (STRICKLAND 1945)	2484 (1410–3900)		185 (112–249)	
Panama (WILLIAMS 1941)	2000			
East Africa (SALT 1952)		11360 (7150–23090)		335 (160–1200)
England (SALT 1952)		10550 (3460–30370)		795 (366–2032)

It may be concluded that the data presented do not give any indication of a consistently lower soil macroarthropod population in the tropics. The composition of the faunas showed distinct differences. For instance, the tremendous richness of Isopoda and Pseudoscorpiones, as recorded in several stations, was never found in the temperate zone. The Diplopoda also occur in densities not known in temperate regions. Isoptera only occur in the tropics, but were only numerous in the inland forest plots.

Perhaps the biggest difference is found in the ant fauna. As against 47 species in the Netherlands, more than 170 species were found in this study, and doubtless there are many more. And the numbers in which they were taken, both in the soil samples and in the alcohol traps, also suggest that this group plays a very important role in the soil community in the tropics. On the other hand, carabids were notably scarce in our samples, and in the pitfall traps only a few species occurred frequently. It seems that the niche occupied by the Carabidae in the temperate zone is filled by Formicidae in the tropics.

Another group, which is obviously scarce in the tropics is that of the Geophilomorpha. This may perhaps be connected with the absence of a humus layer, which accomodates great numbers of this group in the temperate zone.

It may now be asked whether the microarthropods (Acari and Collembola) are quantitatively different in tropical and temperate soils. The total numbers collected in five samples (surface area 20 cm^2 each, depth 3 cm) from each of the stations are given in Table 7. In general, the populations were smaller in cultivated land than in forest; only in the melon field on sand at La Poulle (XVI) was the total number of microarthropods significantly greater than in the forest. The average numbers per dm^2, and the ranges, are given in Table 6. The numbers in the Surinam forest are lower than the average numbers from oak forest in the Netherlands, but the ranges show that the difference is not significant. It is remarkable that the numbers in the fields are rather high compared both with the numbers from the adjacent forest and with the numbers from the arable fields in the Netherlands.

Table 7
Microarthropod numbers per dm² in different Stations (for explanation of Sta. nrs. see Table 2)

	D III	D IV	D V	D VI	D VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XX	XXI	XXII	XXIII
Acari in forest-plots	330			499		129		533		525		376			682		285	288		
in field plots		376	115		355		87		510		142		410	636		502			141	243
Collembola in forest-plots	3			19		8		50		38		102			130		35	23		
in field-plots		5	10		6		3		38		40		33	215		3			9	22
Total microarthropods																				
in forests	333			518		137		583		563		478			812		320	311		
in grassland		381											443			503				
in arable land			125		361		90		548		182			851					150	265

In considering the Surinam forests account must be taken of the fact that a humus layer is absent and that it is just this layer which is the habitat for the majority of mites and springtails. Unlike the fields in the Netherlands, those in Surinam included pastures and orchards. But even when these are excluded, the average number remains greater in the Surinam fields. This high density of microarthropods may possibly be attributed to the fact that most of the fields studied were reclaimed rather recently and had, in general, a dense weed cover.

These results are contrary to those of SALT (1952), who found a smaller microarthropod population in east African pastures than in English pastures (Table 6). DELAMARE DEBOUTTEVILLE (1951) also determined smaller microarthropod populations in west African forests and savannas than in corresponding types of vegetation in France.

From this investigation it appears that the populations of neither macroarthropods nor microarthropods are smaller in Surinam than in the Netherlands.

SUMMARY

1. In the coastal area of Suriname the soil and surface fauna were studied in various types of agricultural land, and compared with the fauna in the adjacent forests.

2. In primeval forest the soil macroarthropods are less numerous than in secondary forest (Formicidae excluded). They range generally from 2,000 to 3,000 per m^2 in the primeval forest and from 3,000 to 4,500 per m^2 in the secondary forest. In cultivated land the numbers range in general from 1,500 to 2,500 per m^2.

In recently reclaimed land the numbers of soil macroarthropods are very small and amount to 15–30% of those in the adjacent forests. In the older agricultural soils they range from 50 up to 130% of the numbers of arthropods in forest soil.

3. The surface fauna is best developed in the secondary forest on shell ridges. In primeval forest the surface fauna is richer in the border zone than in the inner part. In cultivated land most "forest species" decrease strongly in numbers, but they are replaced by

"open field species". The numbers of surface arthropods (Formicidae, Scolytidae and *Pheropsophus* excluded) in the cultivated land are generally 20–40% less than in the adjacent forests.

4. On account of their much more frequent occurrence in forests the following groups were distinguished as forest inhabitants: Isopoda, Diplopoda, Dermaptera, and Staphylinidae. The following may be designated as open-field inhabitants: Lycosidae, Gryllotalpidae, Elateridae and *Pheropsophus* (Carabidae).

5. Of the eleven most frequent indigenous diplopod species, five were exclusively found in forest land; another five were also taken in cultivated land, but in much smaller numbers; and one species only was more numerous in the fields than in the forests. – Three introduced species were found in greater numbers or exclusively in cultivated land. One of these was only taken near Paramaribo, probably the centre of introduction.

6. In the cultivated land the number of ants active on the surface of the soil exceeds that in the adjacent forests by up to 900%. The ant population in the soil of cultivated land is generally only 10–30% of that in forest soils.

7. Three of the 171 species accounted for about one third of all the ants collected. These occurred in nearly all fields and forest plots, and apparently have the widest ecological range. The qualitative composition of the ant fauna in the forests appeared to be much richer than that in the fields.

8. The microarthropod population (Acari and Collembola) in the cultivated land was surprisingly large and averaged 80% of that in the forest land.

9. There were no indications that the soil fauna (macroarthropods as well as microarthropods) is consistently smaller in the Surinam soils than in the Dutch soils. However, the greater production of plant material in the tropics and the absence of litter accumulation point to a more rapid decomposition, caused by a greater biological activity at the higher tropical temperatures.

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Plate Ia. — Citrus orchard on sand, Experimental Garden DIRKSHOOP (IV).

Plate Ib. — Secondary Forest and recently reclaimed tomato field on shell ridge, TAMBAHREDJO (VI, VII).

Plate IIa. — Kapoeweri (secondary forest) and water melon field on shell-ridge, SIDOREDJO (X, XI).

Plate IIb. — Kapoeweri (secondary forest) and pasture on sand, VANK-KOLONIE (XVII, XVIII).

Plate IIIa. — Bush negro field (kostgrondje), 1st year, BOVEN SARAKREEK (XXII).

Plate IIIb. — Bush negro field, 2nd year, BOVEN SARAKREEK (XXIII).

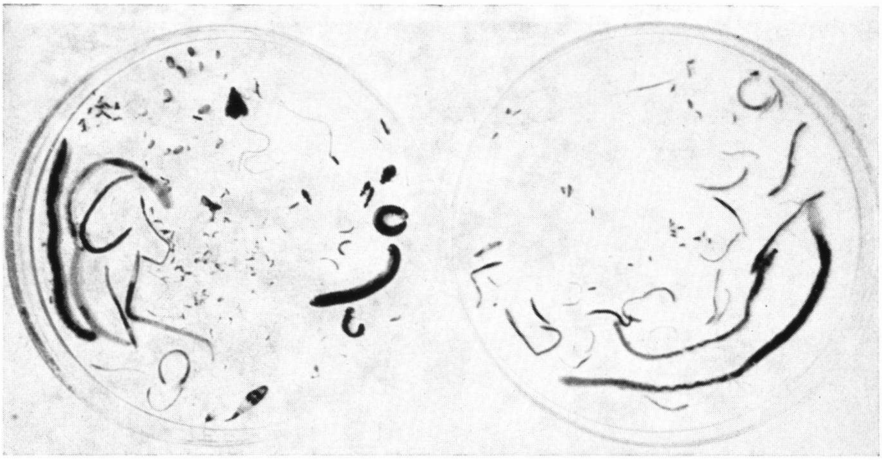

Plate IVa. — Soil fauna in 10 samples each 100 cm², 5 cm depth, from secondary forest on shell-ridge, X (left) and from recently reclaimed melon field on the same soil, XI (right), SIDOREDJO, July 1959.

Plate IVb. — Surface fauna collected during one week in one trap in secondary forest on shell-ridge, VI (left), and in recently reclaimed tomato field, VII (right) TAMBAHREDJO, June 1959.