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NOTE.—Volume 10, Number 4 has been printed in Australia and will be circulated as soon as copies arrive.

Copies of all numbers of the *Gazette* to Volume 7, No. 4, are out of print.

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EDITOR'S NOTE

To conform with previous numbers in this volume, the date of Vol. 11, No. 3 has been made December, 1956. However, the date of issue is February, 1959.

Dr. Shaw's article " A *Deightoniella* disease of *Saccharum* species " was accepted for publication in February, 1958.

from 16 per cent. of the body weight for plant feeders to 2.1 per cent. for active fish eating types.. Food per meal for line caught fish is estimated at double the average quantity found in those stomachs with food in them, based on troll caught southern bluefin tuna. This species of 4.5 kg. average size was found to increase by 13 gm. per day for a food consumption of thirteen times the amount; small horsemackerel may compete with sardines on the New South Wales coast but at a size over 120 mm. in length they eat almost exclusively *Nyctiphanes australis*.

I. INTRODUCTION.

Although food of fishes has been of great interest to biologists for many years, quantitative analyses of the amount of food consumed and relative energy values have only recently been made. Scott (1901) compiled one of the most voluminous records of fish foods ever attempted while McHugh (1952)

mullet *Mugil cephalus* L. (diatoms), butterfish *Coridodax pullus* (Foster) and blackfish *Girella tricuspidata* (Q. and G). higher algae, etc. Horsemackerel *Trachurus declivis* (Jenyns and pilchard *Sardinops neopilchardus* (Steindachner), pelagic filter feeders. Bluecod *Paraperais colias* (Foster), omnivorous bottom feeder. Souhern bluefin tuna*Thunnus maccoyi* (Castlenau), pelagic predator. An examination has been made of the protein content of thirteen different types of fish food.

II. TYPES OF FEEDING AND THE FOOD CONSUMED.

In Table I, the weight of food in the stomachs of different species of fish of various weights is given and expressed also as a percentage of the body weights. The method of obtaining these data has varied according to the different methods of capture and different methods of feeding.

* Chief of Division of Fisheries, Department of Agriculture, Stock and Fisheries, Port Moresby.

TABLE 1.

STOMACH CONTENTS AS A PERCENTAGE OF THE TOTAL WEIGHT AND THE EQUIVALENT PROTEIN REQUIREMENTS OF 100GM. OF EACH SPECIES.

Species of Fish	Food	Average weight of fish—gm.	Average weight of stomach contents—gm.	Percentage stomach of total weight	Equivalent protein food requirements of 100 gm. live weight of each species (gm.)	Remarks
Mugil cephalus	Diatoms	1,079	173.2	16	....	Beach seine, Dargaville Beach, New Zealand.
Girella tricuspidata	Algae Poisodonia	426	56.8	13	.14	Beach seine, Port Hacking, New South Wales.
Corridodax pullus	Algae	2,300	426.0	18	.072	Mesh net, Cook Strait, New Zealand.
Parapercis colias	Salpa miscellaneous	1,045	102.2	10 90	.26	Handlines, Cook Strait, New Zealand.
Sardinops neopilchardus	Copepods Chaetognatha	35	1.5	4.3	.36	Ex. Tuna stomachs, off Albany, Western Australia.
Trachurus declivis	Apogonops Euphausids	850 679	25.5 27.0	4.1 3.9	.52 .27	Trawl net, off Port Hacking. Ring net off Eden.
Kishinoella tonggol	Pilchards	12,190	267.0	2.1	.27	Beach seine, Port Hacking, New South Wales.
Thunnus mccoyii	Pilchards	4,487	106.8	2.4	.31	Troll lines, off Albany, Western Australia.

(1) *Plant eating types.*

(a) *Phytoplankton feeders.*—Stomachs of *Mugil cephalus* were obtained in beach netting on the west coast of New Zealand where great quantities of phytoplankton are accumulated inshore, and mullet feed freely so that the stomachs and intestines are full. As the stomachs of mullet are small, contents of the first half of the alimentary canal were included as in this part no actual digestion appeared to have taken place. Six stomachs were taken of a small shoal and all appeared to be equally full of the diatom *Chaetoceros armatus* Westerndorp (See Chidambaram and Kuriyan 1952, Haitt 1944). These quantities of food are the greatest found in mullet, which often have mixed diatom and sand. In some species small quantities of decaying vegetation are found, probably consumed only under conditions of extreme shortage of food supply.*

(*b*) *Weed browsing feeders.*—The Zoöstera in the stomachs of *Girella tricuspidata* (blackfish) contained a much higher proportion of *Bryozoa* and other animals than stems collected at random by hand from the sea, and the fish obviously seek out the grass beds with a greater percentage of animals attached. This selective feeding was even more marked in the case of *Ulva latuca* where the fish grazed the fronds closely but not so as to kill the plant. Enclosed in the heart is a high proportion of small crustacea and the method of feeding indicates that the fish take the leaves as far as the crustaceans can conceal themselves. A great many blackfish are taken in which there is little food, the three recorded contained the greatest quantity found in a number of fish examined taken with hand lines and beach nets. *Coridodax pullus* (butterfish) feed among brown sea weeds and feed, usually on *Macrocysis* where it prefers the basal spore-bearing fronds, but also eats well developed but young surface leaves excluding floats and stems. The leaves are merely broken up and swallowed in pieces up to one inch square without being chewed. The surface leaves are not usually encrusted with the calcareous growths which are favoured by the *Girella* but the spore bearing basal leaves probably contain a higher percentage of protein than those on the surface. In mesh nets butterfish in their struggles usually regurgitate their food but four fish recently meshed had the stomachs full and the leaves still had the slime covering them as if taken freshly from the sea.

(2) *Bottom Feeding Carnivores*

A number of carnivorous species of fish have been found with algae in their stomachs and the inference that there is a large group of omnivorous species was shown to be incorrect only by a careful examination. It is probable that the only true omnivorous fish are the phytoplankton and algae feeders which consume small quantities of microscopic animals ecologically associated with plants.

In all these species of fish, which are sometimes found with small quantities of algae in the stomachs, it is probable that the reason for eating algae is its effect on the alimentary canal; in the feeding of blue cod in New Zealand algae is consumed only after alimentary upsets caused by shortage of pelagic foodstuffs as clupeoids and other fish and crustaceans such as mysids and whale feed (*Munida*), etc. At these periods, cod are forced to subsist on sea and heart urchins, shellfish and other hard foods which leave the alimentary canal inflamed as the spiny urchins and sharp shells up to one inch in diameter are swallowed whole..

A different feeding at first believed to be of the subsistence type is found when pelagic jellyfish *Ctenophora, Schyphozoa* and *Salpa* swarm. Cod consume great numbers and are fat when feeding on these types of food, the high protein content of *Salpa* on the dry basis shows the considerable food value. In blue cod stomachs, where the food was entirely of *Salpa*, the weight of the stomachs in fish varying from .57 to 1.37 kg., ranged from 6.0 to 7.2 per cent. of the total weight.

As a large part of digestion took place in the small intestine, an examination was made of the contents of that organ to the part where the *Salpa* were more than half

* In the estuary near the west coast where these mullet were feeding, was a thriving mullet fishery at the end of the last century. It declined as few mullet are now taken there. A possible reason, from the evidence of the plankton, is that the estuary changed with the depletion of timber stocks, which caused silting and the production at least in recent years of the spiny diatom *Rhizolenia* which is not usually eaten by fishes.

TABLE 2. PROTEIN CONTENT OF MISCELLANEOUS FOODSTUFFS OF FISHES

(From formalin preserved material.)

No.	Date	Locality	Organisms	Displacement or settled vol. c.c.	Weight wet grams.	Weight dried grams.	Per cent loss in weight	N2 Per cent in dry weight (av.)	Per cent. Protein Average	
									Wet weight	Dry weight
1.	12.5.1951	Limestone Head, S-W Australia	Copepoda	46	8.41	0.81	91	9.5	5.3	59
2.	12.5.1951	Michaelmas Island, S-W Australia	Copepoda	45	10.08	1.09	89	8.4	5.7	52
3.	19.5.1951	Two People Bay, S-W Australia	Sagitta and Copepoda	71	10.18	1.31	87	11.1	8.8	69
4.	20.5.1951	Cape Knob	Copepoda	73	11.85	1.51	87	10.3	8.3	64
5.	24.5.1951	Bremer Bay	Copepoda	42	6.01	0.98	85	10.0	9.3	62
6.	25.5.1951	Doubtful Island	Copepoda and fish larvae	29	3.65	0.61	83	8.4	8.8	52
7.	5.6.1951	½ mile east of Bold Island	Copepoda	48	9.04	0.57	94	8.9	3.4	56
8.	12.6.1951	Off Cape Riche	Copepoda	21	4.93	0.33	93	8.8	3.8	55
9.	14.6.1951	Off Mississippi Bay	Copepoda	15	1.44	0.19	87	8.7	6.8	54
10.	17.6.1951	Bremer Bay	Copepoda	46	5.26	0.70	87	9.3	7.5	58
11.	24.6.1951	100 miles south of Albany	(Aggregate) Salpa maxima	82	11.71	0.48	96	10.2	2.5	63
12.	25.6.1951	20 miles south of Albany	Euphausids and Copepoda	49	8.63	0.96	89	10.7	7.0	64
13.	27.6.1951	Off Albany	Sardinops neopilchardus	14	15.3	2.44	84	12.9	12.9	81
14.	20.11.1952	Sydney Harbour	Metapenqeus macleayi shoot prawn	5	5.8	0.81	86	12.2	10.6	76
15.	7.9.1952	Off Eden	Euphausids (Trachurus stomach)	20 ‡	14.4	1.58	89	6.1	3.7	38
16.	20.10.1952	Port Hacking	Zoostera (blackfish stomach)	20	....	....	92	3.3	1.7	21
17.	16.12.1952	Port Hacking	Ulva lactuca (blackfish feed)	16	7.9 *	0.49	93	2.2	0.9	13
18.	14.12.1952	Port Hacking	Poisodonia (Ribbon weed)	10	9.1	0.73	92	2.3	1.1	14
19.	14.12.1952	Port Hacking	Burley weed (for blackfish)	17	....	....	94	1.6	0.9	10
20.	14.12.1952	Port Hacking	Eklonia	13	....	....	91	2.1	1.2	13
21.	15.2.1952	Port Sorrell, Tasmania	Macrocystis floating fronds	.... †	....	....	89	0.7	0.4	4

* 0.6 gm. Cumacea removed. † Air dried with potash adhering. ‡ Part digested.

digested; this was a stage where the muscular tissue could still be distinguished in most specimens and where the nucleus of the *Salpa*, the last organ to be affected had started to disintegrate; including with the stomach the contents of the alimentary canal to the point at which digestion was half completed, the stomach contents ranged from 8.2 to 10.9 per cent. of the total weight. Many specimens were examined but in no case where the fish were feeding freely on *Salpa* was digestion taking place in the stomach, so that the inclusion of the part of the intestine is justified as representing an extension of the stomach.

Many records describing "jellyfish" being consumed as food have been made. It has not usually been conceded, however, that they are of great importance except perhaps as food for *Mola*. About New Zealand, jellyfish often extend over many miles of the sea and it is possible that the fish have adapted themselves to using small *Aurelia*, *Ctenophora* and *Salpa* as food. The latter species is paricularly important, and in addition to the blue cod in more northern waters, the snapper *Pagrosomus auratus* (Foster), the most important commercial species in New Zealand, feeds almost exclusively on these forms, for some months each year.

(3) *Pelagic Carnivores.*

(*a*) *Tuna.*—In a record of northern bluefin tuna (*Kishinoella Tonggol* Blkr.) caught at Port Hacking in April, 1941, detailed observations on the stomachs of twenty showed the average number of pilchards per meal was nine, their average weight being 267 grams; weight of fish was 12.04 kg. The stomach content being 2 per cent. (Table 2) of the total weight of the fish. In this instance the number of pilchards in the stomachs varied from three to twenty, or from 61 to 565 grams, and the weight of the tuna from 11 to 13½ kg. These fish were captured in a similar gorged condition to shoals of salmon in both southern New South Wales and Western Australia. The fish lie up on occasions for some days and are then usually easily captured.

During a period of six weeks from May to the end of June, 1951, small regular catches of southern bluefin tuna *Thunnus maccoyii* (Castleneau) were obtained in south Western Australia. Of 142 tuna examined, 55 had a total of 123 pilchards in their stomachs in the proportions given in Table 3.

TABLE 3. SHOWING NUMBER OF TUNA WITH FROM ONE TO NINE PILCHARDS IN THEIR STOMACHS.

No. of Pilchard	1	2	3	4	5	6	7	8	9
No. of Tuna	18	22	4	7	....	3	....	....	1

Of these different numbers, the fish with nine pilchards in the stomach may be considered as exceptional—gourmandising—but the other records suggest a pattern of feeding.

If it is assumed that the artificial lure used to catch these tuna is a pilchard, it might be expected that about six pilchards was a full meal and that hungry fish starting their meal would be taken in greater proportion than fish with full or nearly full stomachs. In theory one would hope to obtain equal numbers of fish with none, one, two to five pilchards in the stomach, but the very hungry fish were taken in greater abundance. However, omitting the empty fish, the average number of pilchards in the stomach gives a good approximation to the amount of a half meal and this method may be used for any method of line fishing to determine the amount of food consumed per meal. In the case of the northern bluefin tuna the similarity of the results to the net catch of northern bluefin is confirmation of this theory. It is not possible, however, to state that tuna feed mainly once per day but it is certain that this is the case for a number of species, the exception being when fish become over-full through gourmandising and may not feed for several days. Data in Table 4 gives the average daily increase in weight of tuna caught with troll lines off the coast of south-west Australia.. The fish varied in weight from 2.7 to 8 kg. and are considered all to belong to Group 1. Two exceptionally large fish at nine kg. were not included and ten small fish about one kg. in weight were also omitted. It is not known if the extreme large

TABLE 4. AVERAGE DAILY INCREASE IN WEIGHT OF SOUTHERN BLUEFIN TUNA, MARCH TO JUNE, 1951.

Date of Collection	March 22-26	April 4-15	May 18-25	June 3-9	June 17-19
Average date from calculations	March 24	April 10	May 21	June 6	June 18
Number of fish	35	149	101	77	42
Average weight (gm.)	4,232	4,518	4,961	5,055	5,339
Increase from March 24 (gm.)	....	286.8	673	823.5	110.6
Longest period of days (from March 24)	....	16	57	73	85
Average daily increase (gm.)	....	17.9	11.8	11.3	13.0

and small sized fish are respectively early and late spawning, or if they belong to Groups 0 and 2.

Fishing was concentrated in four periods, the average weight being given for each and over the largest period interval the average weight increase per day. The increase per day of 13.5 grams over the three months is consistent for the four intervals between samples. (See Aust. Nat. Res. Council 1944 for nutrient allowances for domestic animals. Davies 1930, 1931*a* and 1931*b* for growth of plaice in captivity.) A possible explanation of the increase in average weight is that larger fish entered the shoal from an outside source. This, however, is not probable as the length frequency distribution showed only a gradual change.

Assuming the food in the stomach to represent a half daily requirement, the average quantity of food required to produce an increase in weight of the fish is 181 grams, or approximately one thirteenth the food requirements are related to increase in weight. This is a much more efficient process than one would expect in the sea, where the activity in feeding is considerable, and for comparison the food requirements of domestic animals, in which the increase in weight is usually considered to be approximately a fifth of the food intake measured on a dry basis.

The energy expended in feeding varies for active predators but the south-west Australia tuna were never seen feeding very actively, and although fishing was sometimes brisk, the fish on no occasion made sportive leaps which sometimes characterize the movements of tuna in other localities. For comparison also, the feeding activity of Spanish mackerel (*Scomberomorus commerson* Lacepede) in north-eastern Australia and New Guinea may be instanced. This species when feeding has been observed to make leaps of 30-40 feet in the air and the energy requirements to make such a leap are estimated at a minimum of 250 gramme calories..

Fish in feeding on other than jelly-like animals usually fill their stomachs and cease feeding, exceptions are rapacious types which allegedly consume up to 60 pounds weight of other fish to increase their own body weight by a single pound.

In the case of northern bluefin tuna, it was seen that in feeding the stomach filled and then no more is taken until digestion is completed. But in the case of southern bluefin tuna, this does not always appear to be the case, nor can it be definitely said that the tuna feed only once per day, or every two days. However, it is probable that the fish feed once a day; the manner in which tuna in south-west Australia are caught all day long from daylight till dark indicates that although the shoal of tuna feeds to some extent continuously, the proportion of empty stomachs suggests that there is a long period of digestion during which no food is consumed.

(*b*) *Starvation conditions, etc.*—In the water of New Guinea one common tuna species, the yellowfin (*Neothynnus macropterus* J. and E.) is frequently found with *Squilla* larvae in the stomach, and it is considered that tuna feeding on this type of food is virtually at starvation level. Nothing comparable has been found in the southern bluefin tuna in Australian waters, but on the east Australian coast southern bluefin were taken in 1953 with a great variety of demersal fish all of moderate size, in their stomachs, including the snake eel (*Opisurus serpens* L.) and the Nannyai (*Trachichthodes affinis* Regan), while several years previously the stomachs contained for a considerable period, post larval *Cheilodactylidae*. There appears to be little doubt that the catching power of tuna seeking out their prey is very great and the survival of the species will not be jeopardised by a shortage of any one particular type. On the New South Wales coast the usual food of the bluefin tuna is horsemackerel.

(4) *Pelagic Filter Feeders.*

The food of sardines and horsemackerel shows that comparable quantities are consumed by each species on a weight basis. The feeding habits of sardines in south-west Australia have been treated previously (Rapson, 1953) and for comparison horsemackerel is now considered.

Table 5 gives the percentage of various organisms in stomachs of horsemackerel in four size groups and the food consumed progressively changes until the fish reach a size exceeding 120 mm. in length. Even at a size of less than 40 mm. long, a small number of *Nyctiphanes* six and nine mm. long is consumed, the number of abnormally large organisms in the stomach decreases, and only in the largest group are full-sized *Nyctiphanes* found.

From early June in New South Wales adult *Nyctiphanes* shoal and in calm water weather come to the surface where they are preyed upon by a number of species of fish and birds. The horsemackerel are able under these conditions to surround the shoals of *Nyctiphanes* and fill their stomachs in a relatively short time. The amount consumed per meal shows that a dense shoal of horsemackerel comprising 30 tons of fish consumes nearly four tons of feed. The surface migration of euphausids is latest in Tasmanian waters, and the surface shoaling may not start until January.

In periods of cool weather, horsemackerel remain in the mid-water zone where they are seldom captured by fishing methods now in use. In exceptional conditions, small quantities are taken in trawl nets on the bottom where, however, they are usually resting or a small proportion feeding on the demersal forage fish *Apogonops*. This forage species is an important food off the New South Wales coast and flathead (*Platycephalus*) feed on it from below, while *Trachurus* prey on it from above. The relatively small quantity of *Apogonops* consumed by *Trachurus* leads to the assumption that only the small percentage of fish in a shoal feeding on *Nyctiphanes*, which does not obtain sufficient food continues to feed when the greater part of the shoal is resting.

Stomachs of pilchards (130-180 mm. long) in south-west Australia contained 97 per cent. by number of small copepods. This compares

TABLE 5. PERCENTAGE OF VARIOUS ORGANISMS IN STOMACHS OF *TRACHURUS DECLIVIS* OF DIFFERENT SIZES.

Number of Trachurus	Standard length	Organisms in the Stomach			
		Copepods 0.5-2.5 in length.	Other Crustacea etc. 3-9 mm. in length.	9 mm. in length. Nyphiphanes over	Fish.
9	25-40	95	5	....	....
27	41-70	57	30	13	....
22	71-120	39	46	15	....
36	120--360	1	2	96	1

favourably with the contents of *Trachurus* stomachs where the average quantity of copepods is 64 per cent.

The dominant position which horsemackerel hold on the New South Wales coast is probably related to the greater supply of the larger food *Nyctiphanes,* which for approximately six months each year is found near the surface between southern New South Wales and Tasmania.

Several important findings were made in the examination of *Trachurus* stomachs :—

(1) With rare exceptions in individual stomachs, fish are found to feed and the food then is digested over a considerable period, varying as far as can be judged from a minimum of some hours to one or more days. A small shoal of *Trachurus* was found in which most of the fish had in their stomachs the remains of two meals. The organisms in the stomachs were all very small, less than 0.5 mm. in length, and the largest of the fish had in their stomachs the remains of only one meal. It is assumed that they were unable to catch or filter microscopic organisms of this size. The shoal may have been interrupted in feeding, but this is contrary to the findings with pilchard shoals, in which the shoal continued to feed while being preyed upon by tuna. At the time this particular shoal was taken considerable numbers of *Scyphoa* were to be found, and the water was remarkably barren of plankton. The explanation suggested is that the small fish were at subsistence level and the larger fish in the shoal at starvation point.

(2) *Trachurus* are reported by Lettaconnoux 1951 and other writers to consume large quantities of *Scyphozoa*; a careful examination of the stomachs mentioned above showed that with two exceptions the stomachs did not contain scyphozoan or other similar remains and in the two cases the gelatinous matrix which appeared to be part of the tentacle had minute crustacea embedded in it.

. . . .

In ring-net caught fish, it was expected that the greatest quantity of food would be found in the largest fish. Such, however, did not prove to be the case and small fish often had a relatively great quantity of krill in the stomach. An examination of the gill rakers shows that fish over 2½ pounds in weight usually have the long gill rakers bent over in the roof of the mouth which reduces the effective use of these organs considerably. Further evidence of a slackening in feeding activity or in the ability to obtain food was found in a small catch of horsemackerel obtained in trolling for tuna in March and April, 1949. The tuna stomachs contained small fish. These horsemackerel which were feeding among tuna shoals took artificial lures representing fish four to five inches long; their stomachs were empty or contained a few krill. (See California Co-op Sardine Research 1950.) This inability of the older fish to get food may be one of the reasons for the short life span of this species. The age on the Australian coast seldom exceeds eight years.

Although horsemackerel remain in dense shoals for six months in the spring and summer, during the remainder of the year the shoals are somewhat dispersed. The shoaling observed is primarily for feeding, during which period the fish actually spawn and later become somewhat dispersed entering inshore waters.

As shoals in Australian waters are usually more limited in size than most important fish species in the northern hemisphere, observations may be more easily interpreted in terms of shoal behaviour (see Sette, 1949) than for northern hemisphere species, where shoals are large. As feeding is closely related to shoal behaviour the following observations are given :—

Horsemackerel and sardines form shoals for protection, feeding, and spawning; shoals, however, become dispersed under certain feeding conditions when each fish hunts as an individual.

Size of a shoal is limited mainly by the quantity of food available, not in one particular shoal of the forage species but in the average which permits the predator species to obtain food with sufficient ease. Correct water surface conditions (including temperature) and sometimes food are necessary to bring shoals of horsemackerel to the surface. Abnormal cold will drive the shoals to the bottom even in deep water.

As all horsemackerel which were taken in the ring-net contained large quantities of krill in the stomachs, it is assumed that this fish when feeding intensively become less wary. This, in fact, appears to be the case for a number of species, e.g., southern and northern bluefin tunas, salmon and sardines.

One aspect concerning the behaviour of fish shoals, which is quite as difficult of approach as the quantity of food consumed by fish, is the problem of competition for food among fish (see Shorygum 1939, 1946).

III. CHEMICAL ANALYSES.

In Table 2, analyses are given of seven different animals eaten by many species of fish and six plant foods used by a relatively small number of species. Vinogradov (1938) gives the nitrogen content of the other classes of marine organisms, used extensively for food. Protein calculated from his tables for Kiel Bay and other places are as follows: Peridinians varied in protein content from 19.2 to 44.9 per cent. and a single sample of *Ceratium* gave 26.12 per cent.; *Rhizosolenia, Thalassiothrix, Chaetoceros, Skeletonema*, and *Coscinodiscus* 14.1 to 27.8 per cent., the lowest figure being the only analysis of 14 which contained *Coscinodiscus*, the highest contained *Thalassiothrix*; other writers, see Juday (1943), have given analyses for various marine plants. On the basis of dry weight, food protein value can be stated in descending values of protein as follows: Pilchards or fish and prawns then *Sagitta, Copepoda, Euphausia* and *Salpa* approximately equal, followed by peridinians diatoms then *Zoostera, Poisodonia* and *Macrocystis*. There is considerable evidence that weed eaters prefer those parts which harbour the greatest quantities of marine animals. The species which has been observed to feed regularly on *Macrocystis* the butterfish, *Coridodax pullus* in New Zealand prefers the basal spore bearing fronds which probably contain a higher protein content than the floating leaves.

On the basis of wet weights the *Sagitta* and *Salpa* show a lower protein content than those foodstuffs with a comparable protein content determined on the dry basis. They are, however, appreciably higher in protein than vegetable foods. Rapson (1953) shows how pilchards seek *Sagitta* for food and the records of fish consuming jellyfish, Bigelow (1924), Powell (1937), Rapson (unpublished) indicated that although these organisms contain a large quantity of water they are valuable foods. With the exception of *Poisodonia* (which was, however, encrusted with *Brachyura*) the plant samples taken from the sea had a lower protein content than the actual stomach contents of fishes feeding on them, suggesting that the animals living in or on the plant communities may contribute substantially to the food of herbivores. The great range in protein value from 0.4 per cent. to 12.9 per cent. on the wet basis* shows a similarity to the variety of foods consumed by the group mamalia, but is found in a single species of fish or mammal only in unusual circumstances..

Nikolskii (1950) says a fundamental difference between the fertility of soil and the so-called "fish productivity" consists in that in agriculture the first and second links are the economically valuable product, whereas in the sea the economic product is at least the third, and more often the fourth and fifth. This may often be the case, but the smaller quantities of food, rich in protein, which are required by carnivores suggests that the complex food chains may not, in the ultimate production of fish, be less economic than the simple plant feeding of herbivorous mammals. In the sea under natural conditions it is difficult to estimate growth in weight for a given weight of food consumed. The average weight of feed consumed per meal as a percentage of the total weight, however, is a guide to the food value of different foodstuffs (see Chidambaran and others 1952, Venktaraman and Chari 1952, Juday 1943, Clarke and Bishop 1948 for analyses other than protein).

IV. CONCLUSIONS.

Although some fish are found gorged with food, the average quantity consumed per meal varies from approximately 16 per cent. for plant feeders to less than 5 per cent. for fish feeders. For the better type of fish, growth is of the order of one thirteenth of the weight of food consumed estimated on the wet basis. This compares favourably with domestic animals where on the dry basis the increase is only one fifth of the weight of food consumed.

The competition for food in the sea is a problem even more difficult of solution than the food requirements of fish in their natural

* The formalin preserved material is approximately 10 per cent. more concentrated than the living substance.

state. Fish are adapted so that their gill rakers take food of varying size from small species with 150 gill rakers to larger types as tuna with only a few. Yet all species seem able to adapt themselves to an extremely wide range in size of food organisms.

Fish experience periods of subsistence level feeding and starvation conditions but are probably more adaptable tǒ their environment in this respect than warm blooded land animals.

Some little known animals are important in the food of fish and a study of chemical composition is of value in gaining information on the habits of fish and may ultimately prove useful in fishing techniques.

V. ACKNOWLEDGMENTS.

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CONTROL OF THE GIANT SNAIL (ACHATINA FULICA) BY BAITING

L. A. BRIDGLAND, B.Sc. (Agr.), D.T.A. AND P. N. BYRNE, B.Ag.Sc.*

IN parts of New Guinea, where the Giant African Snail (*Achatina fulica*) occurs, successful planting of cacao at stake is almost impossible. Most plantings are made from seedlings grown in nurseries. Planting costs are higher and seedlings do not get such a good start.

In an attempt to find an effective and persistent snail bait, various mixtures have been tried at the Lowlands Agricultural Experiment Station, Keravat. So far, the only effective and practical control has been with baits containing metaldehyde, which is an attractant and a poison.

Following pilot trials, two forms of bait have been selected which are cheap and effective.

1. A cardboard ring coated with a Flintkote/Metaldehyde mixture.
2. Blocks made from cement, sawdust and metaldehyde.

Pilot trials show that the cardboard rings :—

Give complete protection for two to three months before the rings start to break down. Until breakdown occurs, snails have to pass over the rings to get at the seedlings.

The period of effectiveness reduces the snail population to such an extent that seedlings are safe for a considerable time afterwards.

Cement blocks also give good protection and last longer—for up to 12 months. However, our experience indicates that the cardboard rings are preferable.

Manufacture of Baits.

1. *Cardboard Rings.*—

(*a*) Proportions of materials used are :—

Metaldehyde	1 pound.
Flintkote	2 pints.
Dilute Teepol (.05 per cent.)	1 pint.
Water to make	1 gallon.

These amounts will make about 100 baits.

The cardboard rings are made from 0.2 in. plain chipboard strips, 3 ft. 6 in. long by 3 in. wide. This material can be purchased from Australian suppliers in ton lots, at 150 reels to the ton. The paper rolls are also handled in smaller lots by agents in New Guinea.

Cardboard rings protecting young cacao.

Plan view of rings showing extent of overlap.

* Senior Agronomist and Agronomist at Lowland Agricultural Experiment Station, Kerevat, New Britain.

(*b*) Mixing.—To one pound of metaldehyde powder, add gradually one pint of water, to which has been added about 30 drops of detergent. Mix until metaldehyde is in suspension in the form of a paste.

Add two pints of Flintkote and stir thoroughly until the mixture blends. Top up to one gallon with water and again mix.

(*c*) Coating cardboard strips.—The strips are dipped in the mixture, allowed to drain and hung in the shade to dry. The use of shade while drying is important. When dry, staple the strips into rings with an overlap of about ten inches, to stiffen the rings. During the dipping, periodically stir the mixture as the metaldehyde tends to settle out.

2. *Cement Blocks.*—

(*a*) Proportions of materials are :—

Cement	....	1 part by volume.
Sawdust	....	1 part by volume.
Metaldehyde	....	1 part by volume.

(*b*) Mixing.—Before adding sawdust, sieve to remove the coarser material. A sieve with five meshes to the inch was used at Keravat. Thoroughly mix all dry materials and then add water until a fairly wet mixture is obtained.

(*c*) Drying.—Spread out the mixture on wooden trays to a depth of from a quarter to half an inch and allow to dry in the shade. When dry, the bait is broken up into pieces, each of about a square inch.

This bait can be stored for some time.

Costs.—

The cost to bait holes by either method is about twopence. Costs, which include labour, are based on bulk lots of material, landed at Rabaul.

Recommendations.—

From experience at Keravat, the cardboard rings are preferable. Local planters, who have used about 25,000 rings, have expressed complete satisfaction at the results. However, trials have not been critical enough for us to make a firm recommendation.

Methods of use.—

1. Cardboard rings.—Before planting seed, prepare holes in the usual manner and place a ring over each hole. Plant the seed inside the rings. Periodically, the dead snails must be cleared away.

2. Cement blocks.—After planting seed, place four cement blocks around the hole at a distance of about six inches from the centre of the hole. Periodically, clear away dead snails and move the blocks as they tend to become buried in litter.

THE FLAME SPECTROPHOTOMETRIC DETERMINATION OF POTASSIUM, SODIUM, CALCIUM AND MAGNESIUM IN COCONUT WATER

By P. J. Southern.*

The use of coconut water analysis as a guide to the nutrition of the coconut palm was first investigated in Ceylon by Salgado (1, 2). His work has been confined mainly to potassium estimations and shows that the uptake of potassium, as measured by the concentration in the coconut water, is related to the degree of response to potassic fertilizers and to the yield of coconuts in Ceylon. Cassidy (3) has also attempted to relate the potassium content of the nut water with the poor condition of palms in Fiji, but came to the conclusion, based on Salgado's figures, that potassium deficiency was not likely to be a factor in their decline.

Coconut water provides a unique sampling medium in that nuts are easily collected on the ground under individual palms and representative samples of large areas can be taken during the normal harvesting and production procedures. Leaf analysis would involve climbing the palms to cut off fronds, and to obtain representative leaf samples would be a slow and laborious task. It is thought that a system of co-ordinated soil and coconut water analysis may be useful in the diagnosis of the many coconut nutrition problems of Papua and New Guinea.

Salgado (2) used the rather time consuming gravimetric cobaltinitrite method without preliminary treatment for the determination of potassium in routine samples. However, he suggested that the use of flame photometric methods carried out directly on coconut water would be more expeditious for large scale routine analysis. The purpose of the present investigation was to determine whether such methods were sufficiently accurate and precise, not only for the estimation of potassium, but for the other cations in coconut water.

Materials and Methods.

Samples of coconut water, preserved from excessive fermentation by the addition of formaldehyde (1 ml. per 100 ml. sample) were filtered and diluted ten times with distilled water for the estimation. The purpose of the dilution was to bring the concentrations of the cations to within a more accurate range of the instrument and for the convenience of interference and recovery studies.

The instrument used was a Beckman Model D.U. Spectrophotometer with photomultiplier attachment, and oxygen-acetylene flame accessory.

A series of nut water samples taken from Baibara, Papua, and New Ireland, on various soil types, was analysed in a trial run to find the range of concentrations likely to occur during routine work. No allowances were made for interferences or other inaccuracies in the flame method. The results are listed in Table 1. They indicate that the range of concentrations is very wide for all cations. The average concentrations given by Salgado (2) are 32 milli-equivalents per litre for potassium, 4.8 for sodium and 14.3 for calcium. Magnesium is reported to be present in much smaller amounts than calcium. It is apparent from some of the values obtained here that the part played by sodium may be important as it can replace potassium as the dominant cation in the nut water.

Stock standard solutions were made up as follows :—

1. *Potassium.* 100 milli-equivalents per litre. Dissolve 7.456 g. dried A.R. potassium chloride in distilled water and make to one litre.
2. *Sodium.* 100 milli-equivalents per litre. Dissolve 5.846 g. dried A.R. sodium chloride in distilled water and make to one litre.
3. *Calcium.* 25 milli-equivalents per litre. Dissolve 1.251 g. dried calcium carbonate in 25 ml. NHCl. and dilute to one litre with distilled water.
4. *Magnesium.* 50 milli-equivalents per litre. Dissolve 0.61 g. cleaned magnesium ribbon in 50 ml. NHCl. and make to one litre.

* Soils Chemist, Department of Agriculture, Stock and Fisheries, Port Moresby.

TABLE 1. APPROXIMATE CONCENTRATION OF CATIONS IN NUT WATER FROM VARIOUS SOIL TYPES OF PAPUA AND NEW GUINEA.

Sample No.	Potassium m.e./litre	Sodium m.e./litre	Calcium m.e./litre	Magnesium m.e./litre
Baibara A	71.5	7.0	16.0	18
B	55.0	20.5	16.0	18
C	69.0	2.4	16.3	14
D	71.6	6.5	18.0	19
E	78.0	8.2	10.0	14
F	53.7	5.6	8.0	9
New Ireland 1	70.4	21.6	11.5	16
2	65.8	14.0	15.3	19
3	67.2	5.6	13.3	14
4	11.5	39.8	20.3	14
5	65.8	3.0	16.0	16
6	70.4	3.2	15.3	12
7	5.1	67.3	12.0	2
8	5.8	68.4	12.5	3
9	14.1	61.8	12.5	9

The calcium and magnesium solutions were standardized by titration with E.D.T.A. using the method of the U.S. Salinity Laboratory for calcium and magnesium in irrigation waters (4).

These stock solutions were diluted to make up the standard solutions for the flame photometric determinations, the details being set out in Table 2, together with the instrument settings and wave lengths used. Typical calibration curves obtained for the various cations are shown in Figures 1 to 4. Little difficulty was experienced in the estimations except for magnesium, where the sharp arc line at 285.2 milli-microns was used. With the photomultiplier at full sensitivity there were large fluctuations of the meter needle and also a high background reading. Following on the work by Knutson (5), an increased ratio of acetylene to oxygen was used, and more sensitivity was achieved. However, the accuracy of this determination is probably not better than ± 5 per cent.

The flaming of the diluted coconut water samples was carried out after the original solutions had been filtered through two

TABLE 2. FLAME SPECTROPHOTOMETER INSTRUMENT SETTINGS.

Element Determined	Range of Concentration m.e./litre	Slit Width m.m.	Oxygen Pressure lb.p.s.i.	Acetylene Pressure lb.p.s.i.	Wave Length used millimicrons	Phototube
Potassium	0-10	0.10	10	3	770	Red Sensitive.
Sodium	0-10	0.05	10	3	590	Blue Sensitive with photomultiplier.
Calcium	0-2.5	0.04	10	3	423	Blue Sensitive with photomultiplier.
Magnesium	0-5	0.05	8	5	285	Blue Sensitive with photomultiplier.

Whatman No. 5 filter papers, and diluted ten times. The standard oxy-acetylene burner worked satisfactorily for these samples although after many estimations there was a tendency for an incrustation to form on the burner tip due to the organic matter present in the coconut water. Test samples containing 1 per cent. of formaldehyde gave no difference in the emission of the coconut water solutions. The dilution errors involved in adding formaldehyde to the original solutions have been neglected throughout all the determinations.

Experimental Results.

In estimating the accuracy of these flame photometric methods, the effects of the cations, anions and organic matter on the flame emissions at the particular wave lengths and instrument settings were investigated. Recoveries of cations (Table 3) showed that the potassium estimation was highly accurate; the sodium recoveries being consistently slightly high while the magnesium recoveries varied but in the main were low. As was expected the calcium recoveries were low due to the depressing effect of the other ions present.

For the investigation of the anion and organic matter interference on the emission of the cations, 10 ml. samples of undiluted coconut water were passed through columns of the cation exchange resin Amberlite IR-100(H). The cations were completely sorbed, the effluents giving no emission for the four cations. The cations were then released by passing 3N hydrochloric acid through the columns until no trace of the cations was found in the eluate. The acid solutions were evaporated to dryness and the chlorides dissolved and made to a volume of 100 ml. The evaporated solution showed no trace of organic matter, indicating no adsorption on the resin.

A similar series of 10 ml. samples of coconut water was treated in the same way but instead of making the solutions of chlorides to volume, the calcium was precipitated as calcium oxalate. The precipitate was centrifuged, washed, and dissolved in a small amount of dilute hydrochloric acid and made to volume.

The results of the flame estimations for these two series of samples, together with the diluted original solutions are shown in Table 4. The emission of potassium, sodium and magnesium are relatively unaffected by the organic matter and the anions present in the coconut water. Results show the large negative effect on the flame emission of calcium by the anions and organic matter. However, the positive effect of the other cations largely offsets this effect and in most cases the results obtained for the diluted original solution of a varied series of samples are not widely divergent from the calcium result determined after separation as calcium oxalate.

The effects of added cations on the emission of the cation to be determined are shown in Tables 5 to 8. The experimental results show that apart from a slight enhancement of the potassium flame by increased sodium, only the emission of calcium is markedly affected. There is a large positive effect by potassium and a smaller but significant positive effect by sodium. Magnesium, however, decreases the flame emission considerably. The interfering cations were added singly and in concentrations which could be expected in this type of sample.

When many coconut water samples are being received for analysis it is often necessary to store them for several weeks before the analysis can be carried out. An investigation was made to show the effect of storage and deterioration of the sample on the analysis figures. Results which are listed in Table 9 show that there is no great effect despite fermentation and heavy discolouration of samples after storing for three months with formaldehyde added. There is a tendency for the increase in concentration of potassium, calcium and magnesium with a slight opposite effect for sodium.

Discussion.

The estimation of the four principal cations in coconut water can be carried out in a rapid manner, up to 100 samples being analysed in a day and so far over 1,000 samples of nut water have been analysed for the four cations. A complete study of the variation of cation content in coconuts from the same palm and from palms in the same area has not yet been made but indications are that cations can vary considerably between palms in the same vicinity. It is likely, therefore, that sampling variations will be much greater than errors involved in the estimations, with the possible exception of calcium, unless the bulking of many samples

TABLE 3. RECOVERIES OF ADDED CATIONS, m.e./litre.

Sample No.	Potassium added	Potassium found	Per Cent. Recovery	Sodium added	Sodium found	Per Cent. Recovery	Calcium added	Calcium found	Per Cent. Recovery	Magnesium added	Magnesium found	Per Cent. Recovery
1	0	1.12	....	0	5.38	....	0	0.99	....	0	0.72	....
1	2.50	3.70	103	2.50	7.90	101	1.00	1.83	84	1.00	1.72	100
1	5.00	6.10	100	....	....	....	2.00	2.54	78	2.00	2.77	103
2	0	4.30	....	0	3.70	....	0	1.53	....	0	0.91	....
2	2.50	6.79	100	2.50	6.30	104	1.00	2.32	79	1.00	1.86	95
2	5.00	9.28	100	5.00	9.00	106	....	....	....	2.00	2.90	100
3	0	2.81	....	0	4.40	....	0	1.50	....	0	1.00	....
3	2.50	5.34	101	2.50	7.00	104	1.00	2.31	81	1.00	1.90	90
3	5.00	7.70	98	5.00	9.60	104	....	....	....	2.00	2.90	95
4	0	3.03	....	0	3.30	....	0	0.71	....	0	0.67	....
4	2.50	5.53	100	2.50	5.96	106	1.00	1.62	91	1.00	1.60	93
4	5.00	7.97	99	5.00	8.52	104	2.00	2.43	86	2.00	2.49	91

TABLE 4. ANION AND ORGANIC MATTER INTERFERENCE ON DETERMINATION OF CATIONS IN COCONUT WATER.

(Concentration in m.e./litre, diluted solution.)

Sample No.	Potassium found (1)	Potassium found (2)	Sodium found (1)	Sodium found (2)	Calcium found (1)	Calcium found (2)	Calcium found (3)	Magnesium found (1)	Magnesium found (2)
59	1.96	1.96	5.00	5.00	0.80	1.03	0.89	2.1	2.1
88	2.34	2.34	4.63	4.50	1.56	1.68	1.56	2.0	1.8
91	1.28	1.28	6.00	5.88	1.21	1.42	1.25	2.1	2.0
131	7.10	6.96	0.61	0.58	1.06	1.18	....	1.9	1.7
132	6.80	6.67	1.36	1.36	1.18	1.36	1.21	1.7	1.6
145	7.54	7.70	0.58	0.61	1.21	1.25	1.15	1.3	1.1
171	2.70	2.70	5.31	5.17	0.68	0.88	0.74	1.0	1.0
177	3.21	3.21	4.16	4.16	0.80	1.00	0.80	1.0	1.1
182	3.04	3.04	4.22	4.16	0.95	1.18	1.00	1.4	1.3
188	3.50	3.50	2.40	2.40	1.12	1.27	....	1.4	1.4

(1) Original solution, diluted ten times. (2) Free of organic matter, all anions as chlorides. (3) Calcium, free from other cations.

EFFECT OF ADDED CALCIUM ON ESTIMATION OF POTASSIUM, SODIUM AND MAGNESIUM.

Sample	Potassium found, m.e./litre			Sodium found, m.e./litre			Magnesium found, m.e./litre		
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
1	1.13	1.14	1.11	5.35	5.30	5.35	0.70	0.72	0.75
2	4.23	4.23	4.23	3.74	3.76	3.73	0.91	0.98	0.98
3	2.85	2.80	2.78	4.38	4.40	4.44	1.04	1.07	1.04
4	3.00	3.01	3.03	3.24	3.30	3.33	0.67	0.60	0.63

(a) No Calcium added. (b) Calcium concentration increased by 1.0 m.e./litre. (c) Calcium concentration increased by 2.0 m.e./litre.

TABLE 6. EFFECT OF ADDED POTASSIUM ON ESTIMATION OF SODIUM, CALCIUM AND MAGNESIUM.

	Sodium found, m.e./litre			Calcium found, m.e./litre			Magnesium found, m.e./litre		
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
1	5.32	5.35	5.32	0.97	1.09	1.16	0.85	0.80	0.75
2	3.76	3.78	3.80	1.50	1.62	1.70	0.98	0.88	0.91
3	4.52	4.48	4.50	1.51	1.63	1.78	1.10	1.14	1.14
4	3.42	3.43	3.42	0.72	0.77	0.80	0.60	0.63	0.65

(a) No Potassium added. (b) Potassium concentration increased by 2.5 m.e./litre. (c) Potassium concentration increased by 5.0 m.e./litre.

TABLE 7. EFFECT OF ADDED SODIUM ON ESTIMATION OF POTASSIUM, CALCIUM AND MAGNESIUM.

Sample	Potassium found, m.e./litre			Calcium found, m.e./litre			Magnesium found, m.e./litre		
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
1	1.14	1.15	1.18	0.99	1.06	1.09	0.70	0.72	0.70
2	4.28	4.38	4.37	1.50	1.56	1.60	0.91	0.88	0.88
3	2.78	2.81	2.90	1.51	1.57	1.64	1.00	1.07	1.14
4	2.99	3.05	3.07	0.71	0.72	0.75	0.67	0.63	0.67

(a) No Sodium added. (b) Sodium concentration increased by 2.5 m.e./litre. (c) Sodium concentration increased by 5.0 m.e./litre.

TABLE 8. EFFECT OF ADDED MAGNESIUM ON THE ESTIMATION OF POTASSIUM, SODIUM AND CALCIUM.

Sample	Potassium found, m.e./litre			Sodium found, m.e./litre			Calcium found, m.e./litre		
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
1	1.13	1.12	1.13	5.15	5.17	5.20	0.96	0.88	0.78
2	4.23	4.27	4.28	3.69	3.74	3.69	1.48	1.37	1.22
3	2.78	2.73	2.72	4.43	4.30	4.31	1.50	1.37	1.27
4	2.99	2.97	2.99	3.27	3.27	3.30	0.71	0.61	0.56

(*a*) No Magnesium added. (*b*) Magnesium concentration increased by 1.0 m.e./litre. (*c*) Magnesium concentration increased by 2.0 m.e./litre.

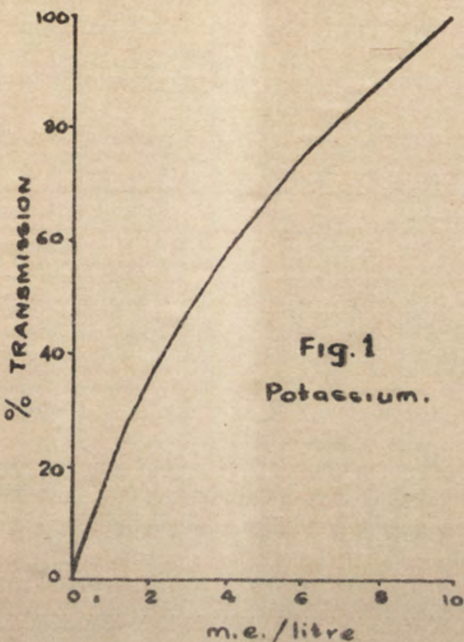
TABLE 9. CHANGES IN CATION CONTENT AFTER STORAGE FOR THREE MONTHS.

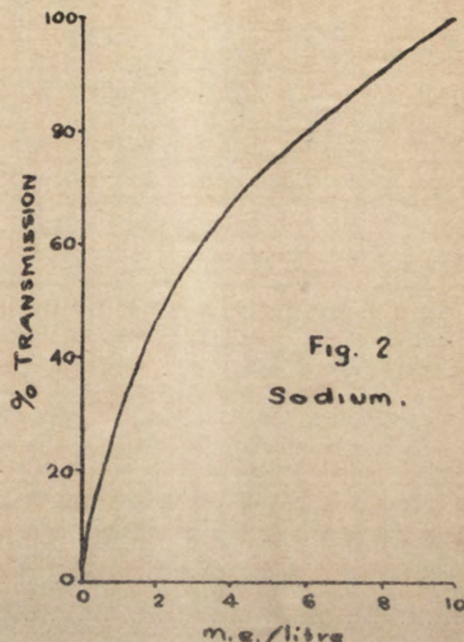
(Concentration in m.e./litre, undiluted nut water.)

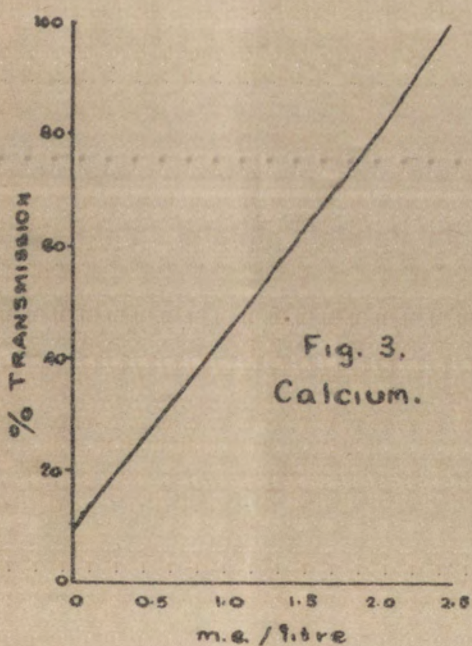
Sample No.	Potassium found		Sodium found		Calcium found		Magnesium found		Colour.
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	
64	26.0	27.9	51.5	50.0	7.7	8.3	8	10	Clear.
58	17.2	18.5	45.6	44.2	9.2	9.8	12	13	Clear.
101	37.0	39.0	30.0	30.1	12.7	13.6	17	18	Clear.
112	21.9	23.4	45.6	44.2	9.5	10.0	13	15	Clear.
98	27.8	27.9	31.2	30.1	10.9	11.5	8	9	Yellow.
75	21.9	22.7	50.0	48.7	10.6	11.5	16	14	Yellow.
36	41.2	41.2	37.4	36.1	7.7	7.7	15	13	Brown.
33	27.0	27.0	41.5	41.6	10.6	10.0	20	22	Brown.
19	22.8	24.3	48.8	48.7	7.1	7.4	12	13	Brown.
89	29.5	30.4	41.5	50.0	10.6	11.5	11	13	Brown.
67	35.0	37.1	44.2	44.2	11.5	12.1	16	16	Yellow-Brown.
83	23.5	22.8	45.6	44.2	4.3	4.6	9	10	Yellow.

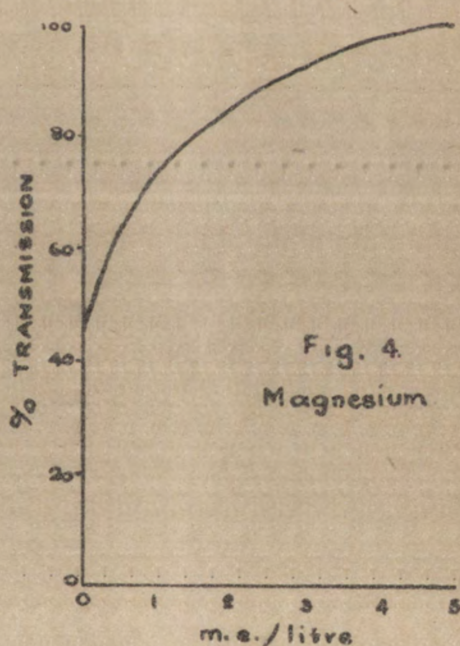
(*a*) Original Estimation. (*b*) Estimation after three months' storage.

TYPICAL CATION CALIBRATION CURVES.









together is used. It is proposed to investigate the E.D.T.A. titration method for calcium and magnesium as this is likely to be more accurate for calcium and magnesium.

The anion content of coconut water consists chiefly of the chloride, sulphate, phosphate and nitrate radicles, and further work on their estimation is contemplated. Surveys of the main coconut producing areas in Papua and New Guinea are being undertaken and samples of soil, coconut water and other plant material are taken from areas of varying production and decline. Nut water analysis is also being used in conjunction with coconut fertilizer trials in order to measure the uptake of nutrients as determined by the concentration in the coconut water. So far, potassium estimations of soil and nut water show that the potassium status of the soil on many plantations is very low, and that the low potassium content in the nut water is accompanied by a high sodium content.

Summary.

A method is described for the rapid routine analysis of the principal cations in coconut water using the Beckman D.U. Spectrophotometer with flame attachment. The method is accurate for the estimation of potassium and sodium. The calcium estimation suffers from cationic and anionic interference, and the magnesium method is rather insensitive for accurate work. Coconut water analysis is being used to study coconut nutrition problems in Papua and New Guinea.

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A DEIGHTONIELLA DISEASE OF SACCHARUM SPECIES.

DOROTHY E. SHAW.*

A LEAF disease called "Veneer Blotch" is reported on *Saccharum officinarum*, *S. robustum*, *S. spontaneum* and *Saccharum* sp. in Papua, New Guinea, New Britain and the British Solomon Islands Protectorate. The genus *Deightoniella* is emended to include species with amerospores, and the causal organism of the disease is described as *Deightoniella papuana* sp. nov.

* * * *

Species of *Saccharum* (*S. officinarum*, *S. robustum* and *S. spontaneum*) collected in Papua, New Guinea, New Britain and the British Solomon Islands Protectorate, have been found with striking leaf lesions caused by a species of *Deightoniella*.

The lesions on all hosts are similar, although a little narrower on the narrow-leaved species, *S. spontaneum*, than on *S. officinarum* and *S. robustum*. The lesion begins as a small, oval spot, light green to straw coloured, with a distinct thin red-brown border on any part of the lamina. It then becomes flanked by two longitudinally elongated similar lesions, resembling wings, one on each side (Plate 1). Two more wings then appear, flanking the first pair, and so on until sometimes twelve wings are formed on each side of the oroginal spot, each successive wing usually being larger than the preceding one. One lesion examined measured 61 cm. long by 1.2 cm. wide. Occasionally the wings on each side are not symmetrical, and very occasionally secondary wings will form parallel to the main chain. The whole lesion has a beautiful pattern, particularly on the upper surface, and is not unlike a veneer of wood. Upon the death of the leaves the pattern is still discernible.

On the upper surface each wing is outlined with a thin dark-red border, 0.5-1 mm. wide. The interior of the lesion is at first light green, later greeny-grey or straw-coloured and finally light brown.

On the under surface of the lesion, the conidiophores form a dense black pile except on the newly-formed wings at the apex and base of the lesion. Occasionally conidiophores also form on the upper surface.

In the field, spores are often found with the conidiophores, although usually detached from them.

They are produced abundantly on the conidiophores, however, if the leaves are kept in a humid atmosphere overnight or longer.

If a common name is required for the disease, "Veneer Blotch" would seem appropriate.

A. Emendation of the genus and description of the species.

On the recommendation of Dr. M. B. Ellis, of the Commonwealth Mycological Institute, Kew, the genus *Deightoniella* is emended to include species with amerospores :—

Deightoniella Hughes *emend*. D. Shaw.—

Colonies on host : effused, black, velvety. *Condiophores* arising close together, singly or in small fascicles, simple, straight or twisted, often elongating by successive subglobose apical proliferations. *Conidia* formed singly as blown-out ends at the apex of the condiophore and each proliferation, o-multiseptate, subhyaline to olivaceous brown or brown, smooth verrucose or echinulate.

Description of the species :

Deightoniella papuana sp. nov.

Coloniae : effusae, atrae.
Conidiophores : densa, singulariter oriunda simplicia, tortuosa, continua, basi inflata (6-9μ) brunnea supra pallidiora, 39-70 (90) x 6-8μ.

Conidia : singula, globosis vel subovoideus, aseptata, minute echinulata, pallide oliveaceo-brunnea, 15-20 x 15-18μ.

Habitat : in follis vivis *Saccharum officinarum* L., *S. robustum* Brandes and Jesweit ex Grassl., *S. spontaneum* L. and *Saccharum* sp. (Gramineae), Papua, New Guinea, New Britain, British Solomon Islands Protectorate. Typus T.P.N.G. 1221, Laloki River, Papua, 10.1.57, D. Shaw, *Saccharum robustum*. Herb. I.M.I. No. 71316.

* Pathologist, Department of Agriculture, Stock and Fisheries, Port Moresby.

The conidiophores of *Deightoniella papuana* form a dense black pile, usually on the under surface of the leaves, although occasionally they form on the upper surface also. They are simple, 39-70 (90) x 6-8μ, dark brown, slightly paler above, cylindrical throughout most of their length but tapering slightly at the tip, with twisted growth, either clockwise or anti-clockwise, as described for *Deightoniella africana* (Hughes, 1952; Ellis, 1957). The number of twists per conidiophore ranges from 8-14. The base is swollen into a bulb, 6-9μ wide and is partly immersed in the cell wall of the epidermal cell. The base of the conidiophore connects with the fungal tissue inside the epidermal cell by a

PLATE 1

Compound lesions on leaves of Saccharum robustum. Note the pattern caused by the development of successive wings beginning initially from the infection court; upper surface (x1).

PLATE 2

Conidiophores and conidia, and one conidium still attached to the conidiophore (x350).

narrow hypha about 2-3μ long. The conidiophores are arranged in more or less straight rows in the cells between the ridges, although some conidiophores issue from the ridge cells themselves; up to four conidiophores were noted issuing from the one cell. The mycelium in the cells is pale olivaceous.

The *conidia* at maturity are globose to nearly ovoid, aseptate, minutely echinulate, very pale olivaceous brown, 15-20 x 15-18μ. No basal scar could be detected. They retain their circular shape during germination.

Habitat: on living leaves of *Saccharum officinarum* L. (chewing cane), *S. robustum* Brandes and Jesweit ex Grassl, *S. spontaneum* L. (cane grass) and *Saccharum* sp. (Gramineae), Papua, New Guinea, New Britain, British Solomon Islands Protectorate. Type T.P.N.G. Accession No. 1221, Laloki River, Papua, 10.1.57, D. Shaw, *Saccharum robustum*. I.M.I. No. 71316. Another collection, T.P.N.G. Acc. 1967, has been given Herb. I.M.I. 71317.

Collections examined.

Locality.	T.P.N.G. Acc. No.	Collector.
Saccharum officinarum—		
Kanosia, Papua	1262	D.S.
Saccharum robustum and *robustum types*—		
Laloki River, Papua	674, 726, 1221, 1967	D.S. D.S.
Keravat River, New Britain	802	D.S. D.S.
Goroka, New Guinea	859	D.S.
Mount Hagen, New Guinea	964	D.S. D.S.
Brown River, Papua	1283, 1552, 1678 1329	
Beipa, Papua	1411	
Tenaru, Guadalcanal, British Solomon Islands Protectorate	1529	C. O. Grassl, J. Warner.
Arona, New Guinea	1845	D.S.
Aiyura, New Guinea	1850	D.S.
Saccharum spontaneum—		
Epo, Papua	432, 651 571	A.W. Charles F. Arndt.
Samarai, Papua	452	D.S.
Popondetta, Papua	617	D.S.
Erap, New Guinea	763	D.S.
Beipa, Papua	1410	D.S.
Port Moresby, Papua ...	1990	D.S.
Saccharum sp.—		
Mount Hagen, New Guinea	965	D.S.

B. Other aspects of the disease

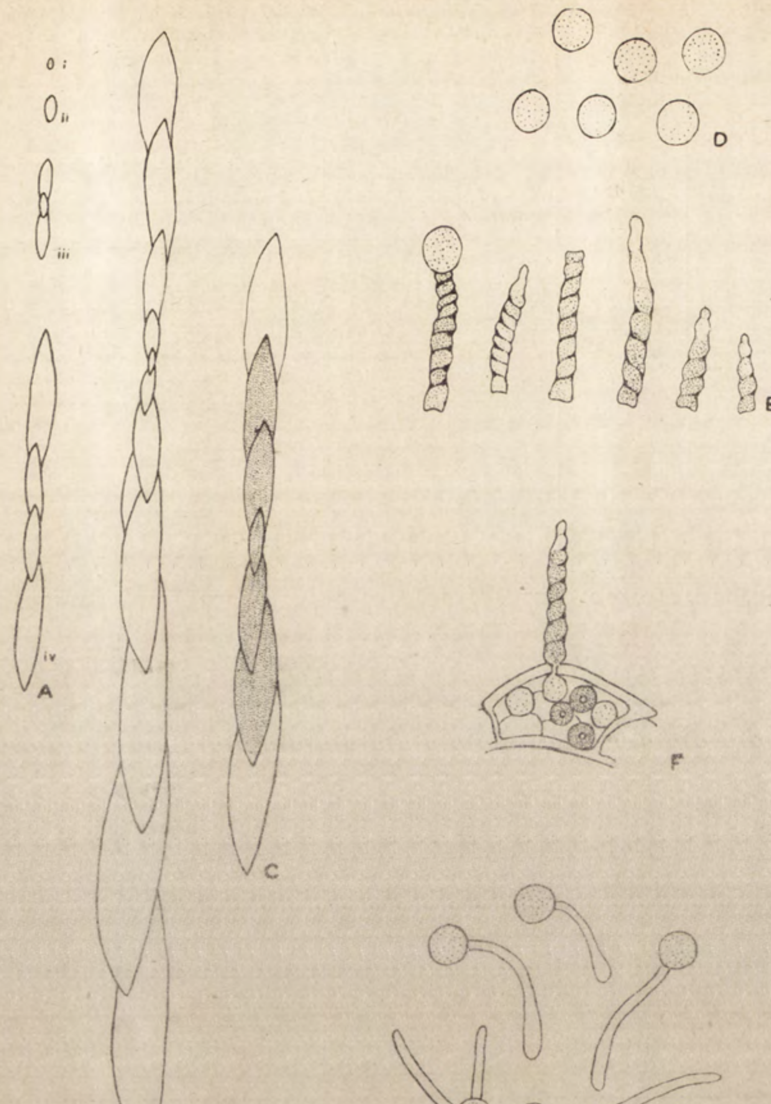
Germination of spores in water was difficult to obtain—very rarely, in fact, did any germinate at all.. Germination occurred overnight, however, when a piece of the leaf was added to the spore suspension. Germination was also obtained overnight when the spores, either dry (having been scraped from the leaf surface with a scalpel) or in a water suspension, were streaked directly on to an agar surface. Germinating spores retained their circular shape, and produced one germ tube, or, more rarely, two, per spore. The germ tubes in water often showed the tendency to end in a small appressorium-like body. Germ tubes on agar surface were often aerial, and, although some reached over 80u in length and branched once, no growth past this has so far been obtained, despite the use of various media held under different conditions. Germination of the spores and growth of the germ tube was slow, whether on agar or in water suspension with leaf fragments.

When surface sterilized pieces of lesions were plated on to agar, either contaminant fungi which produced other spores were obtained, or no mycelium was obtained at all. Conidiophores were also streaked on numerous occasions on to agar, but no growth occurred. This was as expected, because, as Hughes (1952) pointed out, the condiophores are aseptate. When removed from the leaf surface, the condiophores usually break off at the surface, which means that the cytoplasmic connection with the portion in the leaf tissue is broken, so that each detached condiophore is, in fact, a broken cell.

Of the five described species of *Deightoniella*, only one (*D. torulosa*) has been obtained in culture. Germination of *D. torulosa* spores has been obtained, and Ellis (1951) reported that, although the conidia of *D. arundinacea* (then *Napicladium arundinacium*) do not germinate readily in tap water, a few conidia did germinate at the apex in four days, each one forming a single germ tube. Neither germination of spores nor growth in culture has been reported for *D. africana* or the other species.

Ellis (1951, 1957) has reported that infection by *D. arundinacea* is systemic, but this would not seem to be the case with *D. papuana*, where the development of the lesion can be easily traced. Lack of facilities has so far prevented inoculation studies with *D. papuana*.

The hosts of *D. papuana* have a very varied habitat. They were located in dry Eucalyptus savannah (*S. spontaneum*, Papua); in grassland dominated by *Imperata cylindrica* and *Themeda australis* (*S. spontaneum*, New Guinea); in streams and on the banks of streams (*S. robustum*, Papua, New Britain, British Solomon Islands Protectorate); in native gardens in rain forest clearings (*S. officinarum*, Papua); on sandy beach soil on the coast (*S. spontaneum*, Papua); all the above being at or within a hundred feet of sea level. In New Guinea, however, the disease was found in great abundance, and with lesions over two feet long, on *S. robustum* in the valleys of the Highlands, at 5,000 to 6,000 feet.



A. (i-iv) Series of lesions of Saccharum robustum, showing development of wings; upper surface (x1).

B. A large compound lesion, with wings; upper surface (x1).

C. A compound lesion, under surface, showing pile of conidiophores (x1).

D. Conidia, globular, minutely echinulate (x350).

E. Conidiophores in various stages of development, showing clockwise and anti-clockwise twists (x350).

F. Edge cell of leaf of S. spontaneum, showing emergence of conidiophore, the protoplasmic connection, and conidiophore bases (x350).

G. Germinating conidia in water containing leaf fragment with swelling at tips (x350).

The present known distribution of this ;ease is Papua, New Guinea, New Britain d the British Solomon Islands Protectorate. ıe disease is also probably in Netherlands ẹw Guinea. Two of the hosts, S. icinarum and S. spontaneum, are widely ;tributed throughout the Indo-Malayan ;ion, and it will be interesting to note if the ;ease is recorded in the future on any of ẹ islands west of New Guinea.

No species of *Deightoniella* has previously ẹn recorded on *Saccharum*. *D. africana* [ughes, 1952; Ellis, 1957) occurs on *perata cylindrica* var. *africana* in Africa, d *D. arundinacea* (Hughes, 1952; Ellis, 57, and, as *Napicladium arundinaceum*, is *et al.* 1951; Sprague, 1950) occurs on *ragmites communis*. The other three ẹcies described by Ellis (1957) are not :orded on Gramineae.

The condiophores of *D. papuana* and their ıergence from the leaf are very similar to ɔse described for *D. africana*. The spores *D. africana*, however, and of all the other ẹcies of *Deightoniella*, are septate (from e to three septa), whereas those of *D. puana* are aseptate.. Care was taken that ẹ bulbous bases of the condiophores were t mistaken for spores, and that immature ɔres, which possibly had not developed a ɔtum, were not mistaken for mature ones.

So far *D. africana* has not been recorded on *Imperata cylindrica* in the Territory, although this grass is widespread and is one of the dominant species in many areas. *D. arundinacea* has not as yet been recorded on *Phragmites communis*, which is also common in certain areas.

ACKNOWLEDGMENTS.

Grateful acknowledgment is made to Mr. C. O. Grassl and Dr. J. N. Warner for the identification of the hosts and for collection No. 1529; to Messrs. A. W. Charles and F. Arndt for collections No. 432 and 651, and No. 571 respectively; and to Dr. M. B. Ellis, Commonwealth Mycological Institute, Kew, for his advice to emend the generic diagnosis and his help in preparing it.

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NEW INSECT PEST AND HOST PLANT RECORDS IN THE TERRITORY OF PAPUA AND NEW GUINEA

By J. J. H. Szent-Ivany.*

INTRODUCTION.

NEARLY all insect pests, recorded and published from the Territory of Papua and New Guinea up to about the middle of the year 1954 were listed in a technical paper of the South Pacific Commission, compiled by L. J. Dumbleton (3). Some more insects of cultivated plants were mentioned in papers written by J. H. Ardley, J. H. Barrett, J. W. Barrie, E. B. Britton, G. S. Dun, J. L. Gressitt, Sir Guy A. K. Marshall, N. C. E. Miller, J. J. H. Szent-Ivany and J. S. Womersley in the years 1954-58 (See Bibliography: Nos. 1-2, 4-14).

In the present publication 101 new economic records are listed, that is new as far as the author can ascertain. Some of these represent new host plant records, others new insect pest records for the Territory of Papua and New Guinea or for the whole area of the South Pacific Commission. (See the map on the cover of Dumbleton's above-mentioned paper). A few of these have a wide area of distribution, some of them (mainly the stored product pests) are almost cosmopolitan. But they are listed because to the best of the author's knowledge they have not yet been recorded in New Guinea as economic species. Some other insects mentioned in this paper have been known as agricultural pests in New Guinea for many years, but they are quoted under the wrong names in all previous publications. Some species were identified by the author in Port Moresby but the bulk of the material was examined by overseas specialists.

The insect orders, the families within the orders, genera within the families and the species within the genera are listed in alphabetical order. The name of the collector or collectors is given in brackets. Apart from a few Mecopodidae, Coccidae and Formicidae, none of the listed species are considered major or serious pests.

The names of the host plants are printed between inverted commas.

Appreciation should be expressed for the identification of specimens to Dr. W. J. Hall and Mr. E. O. Pearson, the retiring and newly-appointed Director of the Commonwealth Institute of Entomology (London), to the specialists of the Commonwealth Institute and the British Museum (London), to Dr. E. Hardy and Miss A. Adachi of the University of Hawaii (Honolulu), to Mr. F. Gay of the C.S.I.R.O. (Canberra), to Dr. J. L. Gressitt of the Bernice P. Bishop Museum (Honolulu), to Mr. A. May of the Queensland State Department of Agriculture and Stock (Toowoomba), to Dr. C. Willemse of Eygelshoven (Holland) and to Professor E. O. Wilson of Harvard University (Cambrige, U.S.A.). Also to all those who collected the insects, thus enriching the entomological collections of the Department of Agriculture, Port Moresby, and contributing new data to our knowledge of economic insects in Papua and New Guinea.

List of New Records.

COLEOPTERA.

BOSTRYCHIDAE (AMBROSIA BEETLES).

(1) *Rhizopertha dominica* F. Stored Wheatmeal. Port Moresby. (Coll. M. Wraight.)

BRENTHIDAE.

(2) *Miolispa novae-guineensis* Guer. "Hevea brasiliensis" Feeding on the petiolules and on the growing point of rubber seedlings. Sangara Estate, Northern District of Papua. (Coll. W. A. Van den Berk.)

(3) *Miolispa* sp. nr. *aruensis* Kln. Same as the previous species.

(4) *Miolispa* sp. nr. *papuana* Kln. "Crotalaria anagyroides, Hevea brasiliensis". On the petiolules of rubber seedlings and on the flowers of "Crotalaria". Rubber Experiment Station Bisianumu, Central District of Papua (1,500 feet above sea level). (Coll. J. J. H. Szent-Ivany.)

CASSIDIDAE. (TURTLE SHELL BEETLES.)

(5) *Aspidomorpha australasiae* Boisd. "Ipomoea batatas". (Sweet Potato). Leaves. Port Moresby, Central District of Papua. (Coll. J. J. H. Szent-Ivany)

(6) *Aspidomorpha quadriradiata* Boh. "Ipomoea batatas". Fatmilak Village, East Coast of New Ireland. (Coll. J. J. H. Szent-Ivany.)

(7) *Aspidomorpha socia* Montr. "Ipomoea batatas". Lowlands Agricultural Experiment Station, Keravat, New Britain. (Coll. J. J. H. Szent-Ivany.)

* Entomologist, Department of Agriculture, Stock and Fisheries, Port Moresby.

(8) *Metronia papuana* Spaeth. "Ipomoea batatas". Various villages along the East Coast of New Ireland. (Coll. J. J. H. Szent-Ivany.)

CERAMBYCIDAE (LONGICORN BEETLES.)

(9) *Glenea lefebueri* Guen. "Theobroma cacao". In native Cacao Grove near Madang, New Guinea. Stemborer. (Coll. J. Healy.)

(10) *Hoplocerambyx severus* Pasc. "Anisoptera" sp. Stemborer. Department of Forests Area, Lae, New Guinea. (Coll. S. J. Colwell.)

COCCINELLIDAE (LADYBIRDS).

(11) *Epilachna guttatopustulata tricincta* Montr. "Solanum melongena" (Egg Plant). Leaves. Brown River, Central District of Papua. Department of Forests Area. (Coll. J. J. H. Szent-Ivany.)

(12) *Epilachna philippinensis* Dieke. Same as the previous species.

(13) *Epilachna signatipennis* Boisd. Same as the previous two species. Defoliation by the three *Epilachna* spp. very severe.

CUCUJIDAE.

(14) *Oryzaephilus surinamensis* (L). Port Moresby, Papua. Copra. (Coll. W. L. Conroy.)

CURCULIONIDAE (WEEVILS).

(15) *Apirocalus cornutus* Pasc. "Camellia sinensis" (Tea). Foliage. Government Tea Plantation Garaina, Morobe District of New Guinea. (Coll. J. J. H. Szent-Ivany.)

"Coffea robusta". Foliage. Kapurakambo Plantation, Igora Plantation, Northern District of Papua. (Coll. J. J. H. Szent-Ivany.)
"Hevea brasiliensis". Foliage. Rubber Experiment Station, Bisianumu, Central District of Papua. Sangara Estate, Northern District of Papua. (Coll. J. J. H. Szent-Ivany.)

"Persea gratissima" (Avocado Pear). Koitaki Estate, Javerere Plantation, Central District of Papua (Coll. C. Sefton and J. J. H. Szent-Ivany.)

(16) *Elytrocheilus coeruleatus* Pasc. "Theobroma cacao". Foliage. Mamoo Plantation. Northern District of Papua. (Coll. G. Pritchard.)

(17) *Eupholus schonherri* Guer. var. "Theobroma cacao". Foliage. Mamoo Plantation, Northern District of Papua. (Coll. G. Pritchard.)

(18) *Idiopsis caerulea* Fst. "Hevea brasiliensis". Foliage of seedlings. Rubber Experiment Station, Bisianumu, Central District of Papua. (Coll. J. J. H. Szent-Ivany.)

(19) *Idiopsis grisea* Fst. "Hevea brasiliensis". Foliage of seedlings. Rubber Experiment Station, Bisianumu. (Coll. A. Himson.)

"Zinnea elegans". Port Moresby. Ornamental garden. (Coll. W. Chester.)

(20) *Oribius cruciatus* Fst. "Coffea arabica". Foliage. Gurukor Plantation, Morobe District of New Guinea. (Coll. J. H. Ardley and J. J. H. Szent-Ivany.)

(21) *Pantorhytes quadripustulatus* Gestro. "Theobroma cacao". Stemborer. Kusaun Village, Sepik District of New Guinea. (Coll. K. G. R. Newton.)

(22) *Rhinoscapha thomsoni* Waterh. "Hevea brasiliensis, Theobroma cacao". Foliage. Sangara Estate Northern District of Papua. (Coll. J. J. H. Szent-Ivany.)

GALERUCIDAE.

(23) *Aulacophora wallacei* Baly. "Crotalaria anagyroides". Foliage. Goroka, Wallis Plantation. Eastern Highlands of New Guinea. (Coll. J. H. Barrett.)

(24) *Macrima armata Baly*. "Crotalaria anagyroides". Foliage. Goroka, Eastern Highlands of New Guinea. (Coll. J. H. Barrett.)

NITIDULIDAE.

(25) *Carpophilus dimidiatus* F. Stored Wheatmeal. Port Moresby. (Coll. M. Wraight.)

TENEBRIONIDAE.

(26) *Tribolium confusum* Duval. Stored Wheatmeal. Port Moresby. (Coll. M. Wraight.)

DIPTERA.

SARCOPHAGIDAE (FLESHFLIES).

(27) *Sarcophaga* (s.l.) sp. "Hevea brasiliensis". Secondary pest in rubber seeds planted in the nursery after primary attack by the ant *Pheidologeton* sp. Koitaki Estate, Central District of Papua. (Coll. J. J. H. Szent-Ivany.)

TRYPETIDAE (FRUITFLIES).

(28) *Enoplopteron hieroglyphicum* de Meij. "Musa sapientum" (Banana). Agricultural Experiment Station, Bubia, Morobe District, New Guinea. (Coll. J. H. Ardley.)

(29) *Strumeta byroniae* (Tyron). "Capsicum" sp. ("Bird's Eye Chilli"). Samarai, Milne Bay District. (Coll. K. S. Cole.). New record on Solanaceae and new distributon record. In the Australian Zoogeographical Region it was previously known only from Queensland and Netherlands New Guinea. Known host plants: "Cucurbitaceae" and "Passifloraceae". (Information from Mr. A. May.)

HEMIPTERA—HETEROPTERA

LYGAEIDAE (CHINCHBUGS).

(30) *Astacops villicus* (Stal.) "Colocasia" sp. (Native Taro) and "Xanthosoma" sp. ("Kong Kong Taro"). Leaves. Bainyik, Sepik District of New Guinea. Native garden. ((Coll. J. J. H. Szent-Ivany.)

MIRIDAE (CAPSIDS).

(31) *Halticus tibialis* Reut "Phaseolus vulgaris, P. calcaratus, Crotalaria anagyroides, C. striata, C. retusa, Desmodium" sp. Lowlands Agricultural Experiment Station, Keravat, New Britain. (Coll. R. J. Van Velsen.)

(32) *Hyalopeplus* sp. "Crotalaria anagyroides". Kunai Creek Plantation, Wau, Morobe District of New Guinea, 4,000 feet above sea level. (Coll. J. H. Ardley.)

PENTATOMIDAE (SHIELDBUGS).

(33) *Coptosoma concinnula* Walk. "Poinciana regia". Foliage. Agricultural Station, Madang, New Guinea. (Coll. J. J. H. Szent-Ivany.)

(34) *Coptosoma pygmaeum* Mont. "Pueraria phaseoloides, Phaseolus" sp. Covercrops in Coconut Plantation. Kapsu Plantation, East Coast of New Ireland. (Coll. J. J. H. Szent-Ivany.)

HEMIPTERA—HOMOPTERA

APHIDAE.

(35) *Aphis gossypii* Glover. "Malva parviflora". Port Moresby. (Coll. J. H. Barrett.)

(36) *Brachicaudus* sp.? *helichrysi* Kalt. "Crotalaria anagyroides". Lowlands Agricultural Experiment Station, Keravat, New Britain. (Coll. R. J. Van Velsen.)

(37) *Tetraneura hirsuta* Barker. Gramineae (Grass). Roots. Kainantu Airstrip, Eastern Highlands of New Guinea. (Coll. J. H. Barrett.)

COCCIDAE.

(38) *Antonina graminis* (Mask.) Gramineae. Roots. Vaimaru Airstrip, Western District of Papua. (Coll. A. R. W. Litchfield.)

(39) *Aonidiella citrina* (Coq.) "Citrus paradisi" (Grapefruit). Banz, Western Highlands of New Guinea. (Coll. J. J. H. Szent-Ivany.)

"Citrus aurantium" (Orange). Laloki Estate, Central District of Papua. Heavy infestation on fruit. (Coll. W. L. Conroy and R. E. McCormac.). Laloki Quarantine Station. (Coll. J.J. H. Barrett.). Wau, Morobe District, New Guinea, 3,400 feet above sea level. Fruit. (Coll. D. Shaw and J. J. H. Szent-Ivany.)

(40) *Aulacaspis* sp. "Rosa" sp. Stem. Port Moresby. Ornamental Garden. (Coll. Mrs. H. E. Maloney.)

(41) *Chrysomphalus dictyospermi* (Morg.) "Cocos nucifera". On the fronds of semi-mature palms, attacked by Dynastids. Yarapos Village, Sepik District. (Coll. M. J. White.)

(42) *Coccus viridis* (Green). "Camellia sinensis" (Tea). Kararka Tea Plantation, Eastern Highlands of New Guinea. (Coll. A. J. Schindler.)

"Gardenia" sp. Leaves, branches. Port Moresby. (D. De Graff.)

(43) *Dysmicoccus brevipes* (Ckll.) "Oryza sativa" (Rice). Very dense populations on rice roots at the farm of the Roman Catholic Mission, Kanosia, Central District of Papua. (Coll. J. Vanderiet.)

(44) *Eriochiton* sp. "Anona muricata" (Soursop). Lowlands Agricultural Experiment Station, Keravat, New Britain. (Coll. J. H. Ardley.)

"Theobroma cacao". Cleanwater Plantation, Bainings, New Britain. (Coll. J. H. Ardley.)

(45) *Farinococcus simmondsi* Lg. "Cocos nucifera". Tomalabatt Plantation, Tatau Island, Tabar Group, New Ireland District. (Coll. J. J. H. Szent-Ivany.). Mentioned earlier as *Pseudococcus simmondsi* Lg. ? Also known from the British Solomon Islands.

(46) *Ferrisiana virgata* (Ckll.) "Albizzia" sp. Branches. Kinjibi Plantation, Western Highlands of New Guinea. Lunapieve Plantation, Eastern Highlands of New Guinea. (Coll. J. J. H. Szent-Ivany.)

"Coffea robusta". Leaves and branches heavily attacked. Tamaui Plantation, Maprik Subdistrict, Sepik District, New Guinea. (Coll. J. J. H. Szent-Ivany.)

"Hevea brasiliensis". Only a few seedlings infested in the rubber nursery at Koitaki Estate, Central District of Papua. (Coll. C. Sefton.)

"Phaseolus" sp. Port Moresby. (Coll. J. H. Barrett.)

"Plumeria" sp. (Frangipani). Port Moresby. (Coll. D. Shaw.)

(47) *Furcaspis* sp. "Pandanus" sp. Port Moresby. (Coll. J. H. Barrett.)

(48) *Ichnaspis longirostris* (Sign.) "Cocos nucifera". Leaves, Numa Numa Plantation, Bougainville District, New Guinea. (Coll. A. E. Charles.)

(49) *Leucaniodiaspis* sp. "Cocos nucifera". Fronds of mature palms. Aroa Plantation, Central District of Papua. (Coll. J. H. Barrett.)

(50) *Maconellicoccus hirsutus* (Green) "Erythrina indica" (Shade tree in cacao plantation). On the growing point of young trees. Mamoo Plantation, Northern District of Papua. (Coll. J. J. H. Szent-Ivany.)

"Hibiscus rosa sinensis". Serious pest in Port Moresby ornamental gardens. (Coll. J. H. Barrett, D. De Graff and J. J. H. Szent-Ivany)

"Tectona grandis" (Teak). Seedlings attacked in the nursery of the Department of Forests at Port Moresby. (Coll. J. J. H. Szent-Ivany.)

"Theobroma cacao". On the growing point of young cacao trees, retarded in growth also by various Coleopterons, mainly *Apirocalus cornutus* Pasc. and other Celeuthetini weevils. Esambo Plantation, Northern District of Papua. (Coll. F. C. Henderson and J. J. H. Szent-Ivany.)

(51) *Nipaecoccus* sp. "Tamara" sp. Port Moresby. (Coll. J. H. Barrett.)

(52) *Paralecanium* sp "Pandanus" sp. Chwasing, Morobe District of New Guinea. (Coll. R. W. Paine.)

(53) *Parlatoria proteus* Curtis. "Dendrobium" sp. (Orchidaceae). Port Moresby. (Coll. D. Shaw.)

(54) *Monophlebini* sp. "Eucalpytus papuana". Port Moresby. (Coll. F. C. Henderson).

"Eucalyptus alba". Port Moresby. (Coll. L. Edwards.)

(55) *Planococcus citri* (Risso) "Coffea arabica". Mainly damaging flower clusters. There was a serious local outbreak in the Wau Valley in 1956/57. To date populations have been kept under the level of economic injury mainly by the Coccinellid *Cryptolaemus affinis* Crouтch, introduced from the Markham Valley in 1957.

"Coffea robusta". On flower clusters under mud-tents, built by nursing ants. Damage not as serious as to "Coffea arabica" in the Wau Valley. Tamaui Plantation, Sepik District of New Guinea. (Coll. J. J. H. Szent-Ivany.)

"Camellia sinensis" (Tea). Government Tea Plantation, Garaina, Morobe District of New Guinea. (Coll. J. J. H. Szent-Ivany.)

"Leucaena glauca". Leaves and branches of shade trees in various coffee plantations in the Wau Valley, Morobe District (Coll. J. J. H. Szent-Ivany.) "Mangifera indica" (Mango). Fruit thickly covered with mealy bugs. Port Moresby, town area. (Coll. E. Kanjiri.)

"Theobroma cacao". Kubu Plantation, Bougainville District. (Coll. J. H. Barrett). Lowlands Agricultural Experiment Station, Keravat, New Britain. (Coll. J. H. Barrett). Mumm Plantation, near Wewak, Sepik District of New Guinea. (Coll. J. J. H. Szent-Ivany.) "Tephrosia" sp. Leaves and branches attacked. Coffee plantations in the Wau Valley. (Coll. J. J. H. Szent-Ivany).

(56) *Planococcus* sp. "Theobroma cacao". Lassul Plantation, Bainings, New Britain. (Coll. J. J. H. Szent-Ivany.)

(57) *Planococcus lilacinus* (Ckll.) "Theobroma cacao". Pods. Numa Numa Plantation, Bougainville District. (Coll. J. H. Barrett.)

(58) *Pseudococcus* sp. "Theobroma cacao". Pods. Numa Numa Plantation, Bougainville District. (Coll. J. H. Barrett). According to Dr. D. L. Williams (Commonwealth Institute of Entomology, London) who made the identification of all Coccidis mentioned in this paper, this "Pseudococcus" sp was also found in the British Solomon Islands on cacao.

(59) *Saissetia coffae* (Walk.) "Acalypha" sp. Port Moresby. Ornamental garden. (Coll. J. Carter.)

(60) *Saissetia nigra* (Nietn.) "Ceiba pentandra" (Kapok). Ornamental garden at Wakunai Aid Post, Bougainville District. (Coll. J. J. H. Szent-Ivany.)

"Manihot utilissima" (Cassava, Manioc, Tapioca). Aroa Plantation, Central District of Papua. Coll. J. H. Barrett). Brown River, Central District of Papua. (Coll. D. Shaw and J. J. H. Szent-Ivany.) Ornamental "Asparagus" sp. Port Moresby. (Coll. D. De Graff.)

(61) *Steatococcus samaraius* Morr. "Cocos nucifera". Mild attack on fronds of young palms. Kopo Plantation, Tabar Island, New Ireland District. (Coll. J. J. H. Szent-Ivany.)

(62) *Unaspis citri* Comst. "Citrus aurantium" (Orange). The leaves of the orange trees attacked by this Coccus were partly covered with a coccophagous fungus ("Septobasidium" sp. (Det. D. Shaw). Poligolo Plantation, nr. Rigo, Papua. (Coll. E. W. Casey.)

ISOPTERA (TERMITES).

(63) *Microtermes biroi* (Desm.) "Cocos nucifera". Lassul Plantation, New Britain (Coll. J. J. H. Szent-Ivany). Aroa Plantation, Central District of Papua. (Coll. J. H. Barrett.)

(64) *Nasutitermes novarum-hebridarum* (N. and K. Holmgren) "Cocos nucifera". Aroa ("Pig") Island near Kieta, Bougainville District. Large number of palms attacked, mainly those hit by lightning or by shells during the war. (Coll. J. J. H. Szent-Ivany.)

(65) *Neotermes* sp. "Theobroma cacao". Lowlands Agricultural Experiment Station, Keravat, New Britain. (Coll. J. H. Barrett.)

HYMENOPTERA.

FORMICIDAE (ANTS).

(66) *Aphaenogaster pythia* Forel. Damaging airstrip at Kainantu, Eastern Highlands of New Guinea. (Coll. J. H. Barrett). (Species determined by Dr. M. R. Smith.)

(67) *Diacamma rugosum* (Le Guilou). Same as the previous species. (Determined by Dr. E. O. Wilson.)

(68) *Iridomyrmex scrutator* (Fr. Smith) aff. Nursing *Planococcus citri* (Risso), Mealy Bug damaging "Coffea arabica". Wau Valley, Morobe District. (Coll. J. J. H. Szent-Ivany.)

(69) *Iridomyrmex* sp. Nursing *Maconellicoccus hirsutus* (Green), Mealy Bug damaging "Erythrina" and "Cacao" trees. Mamoo Plantation, Northern District of Papua. (Coll. J. J. H. Szent-Ivany.)

(70) *Monomorium* (*Parholcomyrmex*) *destructor* (Jerdon). Damaging electric installation at Aroa Plantation, Central District of Papua (Coll. J. H. Barrett) and in Port Moresby (Coll. J. J. H. Szent-Ivany). Causing serious damage to underground cable by boring into the polythene sheet cover of the cable at Port Moresby. (Coll. V. Hodgson and T. Oliver.)

(71) *Nylanderia bourbonica* Forel aff. Nursing *Planococcus* citri (Risso) on "Coffea arabica" in the Wau Valley. Tent building species. (Coll. J. J.H. Szent-Ivany.)

(72) *Paratrechina* (*Nylanderia*) sp. Causing damage to airstrip at Menyama, Morobe District of New Guinea. (Coll. J. H. Ardley.)

(73) *Pheidologeton* sp. "Hevea brasiliensis". Feeding on planted rubber seeds in a nursery. Koitaki Estate, Central District of Papua. (Coll. J. J. H. Szent-Ivany.)

LEPIDOPTERA.

ARCTIIDAE (TIGERMOTHS).

(74) *Uthetesia lothrix* Cram. "Crotalaria anagyroides". Laloki Quarantine Station and Port Moresby, Central District of Papua. (Coll. J. J. H. Szent-Ivany.)

HESPERIIDAE (SKIPPER BUTTERFLIES).

(75) *Cephenes* sp. near *mosely* Butl. "Cocos nucifera". Commonest "Coconut Skipper Butterfly" in the Port Moresby area. It is able to cause severe defoliation to young ornamented palms, if they are not regularly sprayed. (Coll. J. H. Barrett and J. J. H. Szent-Ivany.)

LIMACODIDAE (CUPMOTHS).

(76) *Scopelodes ursina* Butler. "Coffea robusta". Foliage. Lowlands Agricultural Experiment Station, Keravat. (Coll. K. Newton.)

LYMANTRIIDAE (TUSSOCK MOTHS).

(77) *Dasychira horsfieldi* Saund. subsp.? "Arachis hypogoea" (Peanut). Wewak, Sepik District. (Coll. J. J. H. Szent-Ivany.)

"Theobroma cacao. Foliage. Awala Plantation, Northern District of Papua. (Coll. C. Searle and J. J. H. Szent-Ivany.)

(78) *Orgyia postica* Walk. "Coffea arabica". Foliage. Wau, Morobe District. (Coll. J. J. H. Szent-Ivany.)

NOCTUIDAE (OWLET MOTHS).

(79) *Achaea janata* L. "Ipomoea batatas" (Sweet Potato). Leaves. Embi Plantation (Eriama Estates), Northern District of Papua. (Coll. J. J. H. Szent-Ivany.)

(80) *Heliothis assulta* Gr. "Zea mais". Port Moresby. (Coll. J. J. H. Szent-Ivany.)

(81) *Plusia chalcites* Esp. "Arachis hypogaea" (Peanut). Wewak, Sepik District of New Guinea. (Coll. M. J. White.)

(82) *Polydesma umbricola* Boisd. "Samanea saman" (Raintree). Port Moresby. Park. (Coll. J. J. H. Szent-Ivany.)

(83) *Tiracola plagiata* Walk. "Hevea brasiliensis, Ipomoea batatas, Manihot utilissima" and various indigenous trees of the "weed-line" in young rubber plantation. The larvae of this species were moving in "swarm lines" from the rainforest to a young rubber plantation ("army worms") completely defoliating the rubber stocks, and the plants of the "weed-line". ("Alstonia" sp. and others). From the rubber plantation they moved into a block of Sweet Potato and Cassava, causing complete defoliation. However, they left untouched the "Pueraria phaseloides" covercrop, planted in a part of the rubber block. Ninoa Plantation, Central District of Papua. (Coll. J. Lukin and J. J. H. Szent-Ivany.)

PIERIDAE.

(84) *Catopsilia crocale flava* Butl. "Cassia fistula, Cassia alata". Causes very severe defoliation of "Cassia" sp. in some years in the Port Moresby town area. Almost complete defoliation of "Cassia fistula" was observed in the Wau Valley and in the ornamental gardens of Madang, New Guinea. A mass migration of fertile females in the Wau Valley was seen in November, 1954.

"Tectona grandis" (Teak). A few larvae were found feeding on the leaves of teak seedlings in the nursery of the Department of Forests at Port Moresby. (Coll. J. J. H. Szent-Ivany.)

(85) *Catopsilia pomona* F. subsp.? "Cassia fistula". Foliage. Port Moresby. (Coll. J. J. H. Szent-Ivany.)

PYRALIDAE.

(86) *Agathodes* sp. near *ostentalis* Hb. "Theobroma cacao". Lowlands Agricultural Experiment Station, Keravat, New Britain. (Coll. J. H. Ardley and G. S. Dun.)

"Erythrina indica". Foliage. Mamoo Plantation, Northern District of Papua. (Coll. J. J. H. Szent-Ivany.)

According to an information from Dr. E G Munroe (Science Service, Department of Agriculture, Ottawa) the common *Agathodes* in the Papuan Region represents a new species.

(87) *Corcyra cephalonica* Stt. Stored Wheatmeal. Port Moresby. (Coll. M. Wraight). Stored white rice, Samarai, Milne Bay District. (Coll. M. Luby). A larva was found also feeding in the galls, caused by the rust "Uromycladium" sp. on "Albizzia" sp., planted as shade tree in coffee plantations in the Central Highlands of New Guinea. (Coll. J. B. McAdam.)

PSYCHIDAE (BAGMOTHS).

(88) *Hyalarcta* sp. near *dinavaensis* B. Bak. "Psidium guajava" (Guava). Kokopo, New Britain. Complete defoliation of Guava trees. (Coll. W. Ryder.)

SPHINGIDAE (HAWKMOTHS).

(89) *Deilephila placida* Walk. "Plumeria" sp. (Frangipani). Leaves. Port Moresby. (Coll. Miss M. A. McGrath and J. J. H. Szent-Ivany.)

(90) *Herse convolvuli* subsp.? "Ipomoea" sp. ("Morning-glory"). Feeding on the foliage. Port Moresby. Ornamental garden. (Coll. J. J. H. Szent-Ivany.)

(91) *Theretra nessus* Dry. "Diascorea" sp. (Yam). Foliage. Port Moresby, Central District of Papua; and Lae, Morobe District of New Guinea. (Coll. J. J. H. Szent-Ivany.)

(92) *Theretra oldenlandiae* F. "Impatiens" sp. (Balsam). Larvae defoliating leaves in ornamental garden. (Coll. Mrs. M. L. Szent-Ivany.)

TORTRICIDAE (LEAFROLLERS).

(93) *Homona coffearia* (Nietn.) "Camellia sinensis" (Tea). Government Tea Plantation, Garaina, Morobe District. Low percentage of parasitism by a Tachinid. Larvae and pupae were collected by the author and the parasites were bred in the Entomological Laboratory of Mr. R. S. Paine at Lae, while the author was studying the ecology of rice and peanut pests in the Sepik District. Appreciation should be expressed to Mr. Paine for his helpful assistance.

XYLORYCTIDAE.

(94) *Cryptophasa setiotricha* Meyr. "Samanea saman" (Raintree). Serious pest of ornamental trees in the Port Moresby town area. The larvae feed in the tissues of the stem and the thicker branches. Many branches of affected raintrees are killed as a result of extensive injury by this species. (Coll. D. De Graff and J. J. H. Szent-Ivany.)

"Cassia fistula". Larvae found in the stem of young trees (Coll. E. Kanjiri.)

"Casuarina" sp. Larvae found in the branches of Casuarina trees in the ornamental garden of Taurama Barracks, Port Moresby. (Coll. E. Kanjiri.)

ZIGAENIDAE (BURNETS).

(95) *Leptozyganea gracilis* Jordan. "Pandanus" sp. Cocoons found on the leaves of Pandanus. (Coll. R. S. Paine). This species is very closely related to *Levuana iridescens* Baker, the well-known pest of coconuts in Fiji.

ORTHOPTERA.

MECOPODIDAE.

REMARK.—The following three species were previously known and mentioned in all economic entomological publications (See the list of these in Dumbleton's paper, Bibl. No. 2) under the name of "Sexava" spp. Dr. C. Willemse, who received some material collected by J. H. Ardley in the Admiralty Islands, in New Ireland and New Hanover, found they represented two new species of the Genus *Segestidea*, Bolivar, I., and one new species of the new Genus *Eumossula* Willemse. The description of the new Genus and the three new species was published by Dr. Willemse in April, 1957 (15). Further specimens of Mecopodidae, found on coconuts in Papua and New Guinea, were forwarded to Dr. Willemse by the author in May and June, 1958. This included a new species of the Genus *Pseudoniscara*. The distribution of the four species damaging coconut and African oilpalm in the Territory of Papua and New Guinea is given below:

(96) *Eumossula gracilis* Willemse. " Cocos nucifera ". Fangalava Plantation, New Ireland District (Coll. J. H. Ardley). Masahet Island, Mahurl Island, Lihir Group, New Ireland District (Coll.| J. J. H. Szent-Ivany). Agricultural Experiment Station, Bubia, Morobe District of New Guinea (Coll. J. J. H. Szent-Ivany.)

" Elaeis guineensis " (African oilpalm). Agricultural Experiment Station, Bubia, Morobe District of New Guinea. Lowlands Agricultural Experiment Station, Keravat, New Britain. (Coll. J. J. H. Szent-Ivany.)

(97) *Segestidea hanoverana* Willemse " Cocos nucifera ". Metakabul Plantation, New Hanover. (Coll. J. H. Ardley and J. J. H. Szent-Ivany). Teripax Plantation, Tatau Island, Tabar Group, New Ireland District (Coll. J. J. H. Szent-Ivany.)

(98) *Segestidea insulana* Willemse. " Cocos nucifera ". Pak Island, Lou Island, Lorengau (Manus District) (Coll. J. H. Ardley). Masahet Island, Lihir Group, New Ireland District. (Coll. J. J. H. Szent-Ivany.)

(99) *Pseudoniscara szentia* Willemse* (Cocos nucifera ". Uamai Village, Kerema District, Papua. (Coll. S. Mai.)

PHASMIDAE (STICK INSECTS).

(100) *Angaliale maculata* Oliv. Wide spread minor pest of Cacao on the Gazelle Peninsula of New Britain. (Coll. G. S. Dun.)

THYSANOPTERA.

(101) *Taeniothrips nigricornis* (Schmutz) " Crotalaria anagyroides ". Lowlands Agricultural Experiment Station, Keravat, New Britain. (Coll. R. J. Van Velsen.).

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* According to Dr. Willemse, this is a species of the family Conocephalidae (subfamily Agroecinae). (See Dr. C. Willemse : " On some Tettigonioidea injurious to Coconut Palms ". Naturhistorisch Maandblad 47e Jrg. No. 9-10, 31.10.1958. pp. 122-125).

† Due to publication delay, some papers were printed considerably later than the dates of the periodicals indicated.

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