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## VORREDE.

Im Kaiserreich Japan existieren jetzt im Ganzen 47 selbstständige landwirtschaftliche Versuchs-Stationen, von denen eine durch die Centralregierung, 42 durch Provincialregierungen unter Beihilfe aus der Staatscasse und die übrigen vier vom Adel unterhalten werden. Die unmittelbar der Centralregierung gehörende, d. h. kaiserliche landwirtschaftliche Versuchs-Station besteht aus einer Central-Versuchs-Station, in Nischigahara bei Tokio, und drei unter der Leitung derselben arbeitenden Zweig-Stationen in den Provinzen.

Diese Versuchs-Stationen haben naturgemäss in erster Linie mit Fragen unserer Landwirtschaft sich zu beschäftigen und zwar die kaiserliche Central-Station mehr mit wissenschaftlichen, die provinciellen u. sonstigen Stationen hauptsächlich mit praktischen. Da unsere landwirtschaftlichen Produkte aber nicht nur vielfach andere sind als in Europa, sondern auch die Sumpfkultur<sup>1)</sup> eine weit wichtigere Rolle spielt als in den meisten anderen Kulturländern, sind die alljährlichen Berichte unserer Versuchs-Station bisher lediglich in unserer Muttersprache veröffentlicht worden.

Da jedoch manche der erhaltenen Resultate auch für weitere Kreise einiges Interesse haben dürften, hat sich der Unterzeichnete entschlossen, von Zeit zu Zeit ein Bulletin in abendländischen Sprachen, theilweise in

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1). In Japan nimmt die Reiskultur die erste Stelle ein. Ferner wird *Sagittaria* wegen der Knollen, *Nymphaea* wegen der Wurzel und *Juncus* wegen industrieller Verwendung im Sumpf kultiviert.

deutscher, teilweise in englischer, herauszugeben, worin die von den Beamten unserer Versuchs-Station durchgeführten Arbeiten beschrieben sind.

Die Arbeiten unserer Versuchs-Station sind in folgende Abteilungen gegliedert :

1. Abteilung für Ackerbau.
2. „ „ Agrikulturchemische Untersuchung und Düngerkontrolle.
3. „ „ Pflanzenpathologie.
4. „ „ Landwirtschaftliche Entomologie.
5. „ „ Bodenuntersuchung.
6. „ „ Tierernährung
7. „ „ Tabakbau.
8. „ „ Theekultur
9. „ „ Gemüse und Obstbau.

Den Zweig-Stationen sind die Arbeiten dieser Sectionen teilweise zugeweiht und zwar der ersten Zweig-Station bei Osaka (Mittel-Japan) die der ersten Abteilung, der zweiten bei Kumamoto (Südwesten) die der dritten und vierten Abteilungen und der dritten bei Akita (Nordosten) die der sechsten Abteilung.

Prof. Y. KOZAI.

Direktor der kaiserlichen landwirtschaftlichen Versuchs-Station.

Tokio, Juni, 1905.

# On the Influence of Calcium and Magnesium Salts on Certain Bacterial Actions.

BY

S. MACHIDA.

It is a well known fact that a great excess of lime over the other mineral nutrients can retard the growth of green plants. Further, it has been shown by Kossowitsch, that a certain amount of lime compounds can exert a retarding influence upon the humification process, which doubtless is an action of fungi. It was therefore of some interest to observe also the influence of lime compounds on the activity of the microbes causing putrefaction, especially since gypsum is often applied in stables as well as on compost heaps.

On the other hand it was of value to compare the action of calcium salts with those of magnesium salts, which latter are indispensable for the growth of fungi while calcium salts are generally not. Only for the development of *Azotobacter* the need of lime has been recognised by Gerlach and Vogel and by H. Fischer. These authors also state that denitrification is increased by addition of lime.

In my first experiment the putrefaction of urine was observed<sup>(1)</sup> under the influence of 0.3% of the following salts:

- |    |      |                          |
|----|------|--------------------------|
| a. | 0.3% | Calcium chlorid.         |
| b. | „    | Magnesium chlorid.       |
| c. | „    | Sodium chlorid.          |
| d. | „    | Monopotassium phosphate. |

Three Erlenmeyer's flasks were so connected that a current of air could be passed through them by means of an aspirator. The first contained dilute sulphuric acid to absorb traces of ammonia contained in the air, the second received 300 cc. of fresh urine, the third contained standard sulphuric acid.

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1). At the ordinary temperature in the month of May.

The ammonia formed by putrefaction in flask (B) was partly passing into the flask (C) containing standard sulphuric acid and was here determined by titration, partly it remained in the putrefying liquid from which 20 cc. were withdrawn for the determination by Schloesing's method, taking care to stop further putrefaction of this portion by addition of chloroform. Every determination was carried out twice.

Soon after starting the experiment it was noticed that in the flask with  $\text{CaCl}_2$  a precipitate was formed. After one week the flask with  $\text{MgCl}_2$  assumed a deep brown color, while the other flasks showed this change six days later than the flask with magnesium chloride.

This seemed to indicate that bacterial activity was increased by adding the magnesium salt, but retarded by the calcium salt.

The original urine was found to contain 0.811% nitrogen. The ammonia-nitrogen found in course of the putrefaction process was expressed in percents of the original nitrogen.

## I. PERIOD.

After 5 days from start (May 2).

	N of the $\text{NH}_3$ formed, in percent of the original quantity of nitrogen.		
	in the urine.	in the flask containing standard $\text{H}_2\text{SO}_4$ .	Total.
$\text{CaCl}_2$ ... ..	14.808	—	14.808
$\text{MgCl}_2$ ... ..	20.106	0.016	20.122
$\text{NaCl}$ ... ..	18.952	0.005	18.957
$\text{KH}_2\text{PO}_4$ ... ..	18.476	0.011	18.487
No addition ... ..	19.594	0.007	19.601



## II. PERIOD.

After further 5 days (10 days from start).

		N of the $\text{NH}_3$ formed, in percent of the original quantity of nitrogen.					
		in the urine.		in the flask containing standard $\text{H}_2\text{SO}_4$ .		Total.	
		Newly formed	Since the start	Newly formed	Since the start	Newly formed	Since the start
$\text{CaCl}_2$	... ..	8.966	23.774	0.015	0.015	8.981	23.789
$\text{MgCl}_2$	... ..	54.036	74.142	0.172	0.188	54.208	74.330
$\text{NaCl}$	... ..	64.191	83.143	0.148	0.153	67.339	86.296
$\text{KH}_2\text{PO}_4$	... ..	67.180	85.656	0.136	0.147	67.316	85.803
No addition	... ..	36.035	55.629	0.131	0.138	36.166	55.767

## III. PERIOD.

After further 10 days (20 days from start).

		N of the $\text{NH}_3$ formed, in percent of the original quantity of nitrogen.					
		in the urine.		in the flask containing standard $\text{H}_2\text{SO}_4$ .		Total.	
		Newly formed	Since the start	Newly formed	Since the start	Newly formed	Since the start
$\text{CaCl}_2$	... ..	57.482	81.256	0.086	0.101	57.568	81.357
$\text{MgCl}_2$	... ..	14.378	88.520	0.521	0.709	14.899	89.229
$\text{NaCl}$	... ..	8.465	91.608	0.462	0.615	8.927	92.223
$\text{KH}_2\text{PO}_4$	... ..	4.717	90.373	0.623	0.770	5.340	91.143
No addition	... ..	34.363	89.992	0.734	0.872	35.097	90.864

## IV. PERIOD.

After further 5 days (25 days from start.)

	N of the NH <sub>3</sub> formed, in percent of original nitrogen.					
	in the urine.		in the flask containing standard H <sub>2</sub> SO <sub>4</sub> .		Total.	
	Newly formed	Since the start	Newly formed	Since the start	Newly formed	Since the start
CaCl <sub>2</sub> ... ..	11.013	92.269	0.281	0.382	11.294	92.651
MgCl <sub>2</sub> ... ..	—	87.491	0.371	1.080	—	88.571
NaCl ... ..	—	87.491	0.346	0.961	—	88.349
KH <sub>2</sub> PO <sub>4</sub> ... ..	—	87.388	0.209	0.979	—	90.632
No addition... ..	—	88.791	0.309	1.181	—	89.972

For the second experiment pepton was selected. The arrangements were the same as in the first experiment; the only difference was that in place of the urine 300 cc. of a two percent pepton solution, were employed containing 0.256%N to which 3 cc. of putrid urine was added for infection. The determination of ammonia in the solution was further made by distillation with magnesia usta. This experiment was carried out at summer temperature, in June. The examination showed, that in this case all ammonia remained in the solution, nothing passed into the standard sulphuric acid. The average results of two trials were as follows :

## I. PERIOD.

After 5 days from start, (June 8).

	N of the ammonia formed.	
	in % of pepton-nitrogen.	in % of the original solution.
CaCl <sub>2</sub> ... ..	33.568	0.0860
MgCl <sub>2</sub> ... ..	39.695	0.1017
NaCl ... ..	36.144	0.0926
KH <sub>2</sub> PO <sub>4</sub> ... ..	57.211	0.1466
No addition ... ..	34.660	0.0888

## II. PERIOD.

After further 6 days (June 14).

	N of the ammonia formed.		
	in % of pepton-nitrogen.		in % of the original solution.
	Newly formed	Since the start	Since the start
CaCl <sub>2</sub> ... ..	29.820	63.388	0.1624
MgCl <sub>2</sub> ... ..	30.445	70.140	0.1797
NaCl ... ..	31.764	67.908	0.1739
KH <sub>2</sub> PO <sub>4</sub> ... ..	24.014	81.225	0.2087
No addition ... ..	29.235	63.895	0.1637

## III. PERIOD.

After further 6 days (June 20).

	N of the ammonia formed.		
	in % of pepton-nitrogen.		in % of the original solution.
	Newly formed	Since the start	Since the start
CaCl <sub>2</sub> ... ..	18.735	82.123	0.2103
MgCl <sub>2</sub> ... ..	21.155	91.295	0.2339
NaCl ... ..	19.797	87.705	0.2247
KH <sub>2</sub> PO <sub>4</sub> ... ..	8.861	90.086	0.2308
No addition ... ..	19.712	83.607	0.2142

## IV. PERIOD.

After further 5 days (June 25).

	N of the ammonia formed.		
	in % of pepton-nitrogen.		in % of the original solution.
	Newly formed	Since the start	Since the start
CaCl <sub>2</sub> ... ..	6.909	89.032	0.2281
MgCl <sub>2</sub> ... ..	8.237	99.532	0.2550
NaCl ... ..	4.332	92.037	0.2358
KH <sub>2</sub> PO <sub>4</sub> ... ..	0.114	90.200	0.2311
No addition ... ..	5.500	89.110	0.2283

In the third experiment gypsum and other sulphates were compared as to their influence upon a putrefying medium. Here also served 300 cc. of a two percent pepton solution containing 0.2597% of N, which were kept at the ordinary temperature in the months September and October. The arrangements, treatments and the method of nitrogen determination were the same as in the case of the second experiment. The quantities of the salts added to the pepton solution were as follows :

- a. CaSO<sub>4</sub> (gypsum unburnt). 0.5%
- b. MgSO<sub>4</sub> in equivalent amount.
- c. Na<sub>2</sub>SO<sub>4</sub> „ „
- d. No addition.

The percentage amount of gypsum, and molecular equivalents of the other two salts given, relate to the anhydrous state.

One day after the experiment had commenced, the flasks with MgSO<sub>4</sub> showed much turbidity and a thick white film indicating a vigorous development of bacteria, while the other three sets only showed a slight turbidity. The average results of two trials are contained in the following tables.

## I. PERIOD.

After 5 days from the start (Sept. 20).

	N of the ammonia formed.	
	in % of pepton nitrogen.*	in % of the original solution.
CaSO <sub>4</sub> ... ..	32.308	0.0840
MgSO <sub>4</sub> ... ..	36.961	0.0961
Na <sub>2</sub> SO <sub>4</sub> ... ..	29.769	0.0774
No addition ... ..	30.077	0.0782

## II. PERIOD.

After further 5 days (Sept. 25).

	N of the ammonia formed.		
	in % of pepton nitrogen.		in % of the original solution.
	Newly formed	Since the start	Since the start
CaSO <sub>4</sub> ... ..	24.769	57.077	0.1484
MgSO <sub>4</sub> ... ..	26.116	63.077	0.1640
Na <sub>2</sub> SO <sub>4</sub> ... ..	31.308	61.077	0.1588
No addition ... ..	25.269	55.346	0.1439

## III. PERIOD.

After further 10 days (Oct. 5).

	N of the ammonia formed.		
	in % of pepton nitrogen.		in % of the original solution.
	Newly formed	Since the start	Since the start
CaSO <sub>4</sub> ... ..	16.461	73.538	0.1912
MgSO <sub>4</sub> ... ..	15.961	79.038	0.2055
Na <sub>2</sub> SO <sub>4</sub> ... ..	18.192	79.269	0.2061
No addition ... ..	16.577	71.923	0.1870

## IV. PERIOD.

After further 10 days (Oct. 15).

	N of the ammonia formed.		
	in % of pepton nitrogen.		in % of the original solution.
	Newly formed	Since the start	Since the start
CaSO <sub>4</sub> ... ..	6.923	80.461	0.2092
MgSO <sub>4</sub> ... ..	—	79.038	0.2055
Na <sub>2</sub> SO <sub>4</sub> ... ..	2.269	81.538	0.2120
No addition ... ..	3.115	75.038	0.1951

It will be seen from these results that magnesium chlorid had some favorable action upon the process of putrefaction, while calcium chlorid had not. Calcium chlorid showed especially in the case of putrifying urine a considerable retarding action, which was naturally not more so striking toward the end of the putrefaction.

Calcium sulphate did not act upon the putrifying process, probably on account of its low solubility; magnesium sulphate promoted the putrifying activity only in the beginning. Sodium salts seem to act favorably upon the progress of putrefaction, but the influence is not so marked as with magnesium salts.

In the fourth experiment tricalcium phosphate and sodium phosphate were compared, in which the following solutions (200 cc.) were used.

	a	b
Asparagin	1.00%	1.00%
Cane sugar	1.00 „	1.00
K <sub>2</sub> S O <sub>4</sub>	0.20 „	0.20
MgS O <sub>4</sub>	0.01 „	0.01
Ca(PO <sub>4</sub> ) <sub>2</sub>	0.20 „	—
Na <sub>2</sub> HPO <sub>4</sub>	—	molecular equivalent to Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>

These solutions were after sterilization infected respectively with *B. fluorescens liquefaciens*, *Proteus vulgaris*, and *B. mycoides*. For comparison

served the infection with one drop of putrid urine. The infected solutions were kept at the ordinary temperature from Sept. 15 to Oct. 5. The ammoniacal nitrogen was determined by distilling 20cc. of the solution with magnesia usta. The results were after 3 weeks standing as follows :

	N of the ammonia formed.	
	In % of the original solution (average of two determ.).	
	$\text{Ca}_3(\text{PO}_4)_2$	$\text{Na}_2\text{HPO}_4$
<i>B. fluorescens</i> liq. ... ..	0.100	0.120
<i>Proteus vulgaris</i> ... ..	0.090	0.130
<i>B. mycoides</i> ... ..	0.060	0.060
Urine ... ..	0.120	0.100
Average ... ..	0.0925	0.1025

From this experiment it will be seen that in both cases the phosphoric acid was assimilated by the bacteria nearly to the same extent. It is probable however that there is previously formed some magnesium phosphate from both the phosphates applied. The behavior of bacteria towards insoluble phosphates in the soil is also from the practical standpoint an interesting problem.

Another important subject in this line is the influence of various salts upon the loss of nitrogen, because a favorable condition of putrefaction frequently also favors denitrification. 200 grms. of sifted soil were well mixed with 0.3% of the salts above mentioned and 20 grms. of powdered soy bean cake, as the source of nitrogen. The mixture was placed in a conical flask arranged just in the same way as in the foregoing experiments.

After standing for 64 days (from April 7 to June 10) at the ordinary temperature, the nitrogen was determined with the following result :

I. Total amount of N contained in each flask before the experiment.

		in grms.
Organic nitrogen	{ in soil.	0.572
	{ in oil cake.	1.403
Ammoniacal nitrogen	in soil.	0.004
Nitric nitrogen	.. ..	0.010
Total		1.989

## II. Total amount of N contained in the flasks after the experiment.

	Organic N, g.	Ammonia N, g.		Nitric N, g.	Total.
		in soil	in standard H <sub>2</sub> SO <sub>4</sub>		
CaCl <sub>2</sub> ... ..	1.985	0.052	0.002	0.044	2.083
MgCl <sub>2</sub> ... ..	1.997	0.039	0.002	0.039	2.077
NaCl ... ..	2.144	0.070	0.003	0.050	2.267
HK <sub>2</sub> PO <sub>4</sub> ... ..	1.981	0.053	0.010	0.026	2.070
No addition ... ..	1.895	0.065	0.003	0.037	2.000

From the above figures it will be seen that none of the salts added favored denitrification. On the contrary a very small gain of nitrogen was observed, probably due to certain bacteria capable of assimilating free nitrogen. The results might however have differed after a special infection with a large amount of denitrifying microbes.

It was in this connection also of interest to compare the effects of lime and magnesia salts on the nitrifying process.

It was already found by Wagner that an addition of carbonate of lime especially to humus soil acts very favorably on the nitrification.<sup>1)</sup> It was further observed that application of lime especially on heavy loam soil enhances all bacterial activities in the soil. But thus far no comparison was made of this effect of lime with that of magnesia. My observation that magnesia enhances putrefaction much more so than lime made it very probable that this would also be so with the nitrifying bacteria.

According to Warington<sup>2)</sup> gypsum favors nitrification in putrid urine. Hereby however gypsum is transformed into carbonate. He also stated that small quantities of alkali carbonate (0.368 grms. per liter) also ammonium carbonate stops the nitrification process what has been confirmed by Chuard.

1). Polzeniusz (1898) observed that it is chiefly the lime in the form of carbonate which favors nitrification of the soil, in all those cases in which the nitrogen is applied as ammonium sulphate.

2). J. B. Agr. Chem. 1886.



Pichard<sup>1)</sup> states that gypsum acts favorably on nitrification in porous soils in other soils reduction to sulphide by bacterial activity might result which would injure the nitrification process.

According to Wagner the most favorable case was, when he applied 5 grms. marl upon 300 grms. of soil. Thus 90 parts of nitrate nitrogen were obtained from each 100 parts of ammoniacal nitrogen in the nitrifying process. He applied for 300 grms. soil only 0.1 nitrogen (=0.471 grms. ammonium sulphate) and observed a very much quicker action in the warm house than at the ordinary temperature. He used a small glass flask 6.5 cm. wide and 17 cm. high and every 12 days he transferred the contents of 2 parallel flasks in liter flasks, each was filled up to the mark with distilled water and after shaking repeatedly he determined in the filtrate the nitric acid which was apparently carried out after Schultze-Tieman. According to the above principle I have arranged my experiment in the following way :

Two glass cylinders of about 1 liter capacity were filled with 1 kilogram of fine quartz sand with an addition of 20 grms. of garden soil and to one of which 1 gm. of calcium carbonate and to another 1 gm. of magnesium carbonate were added ; both cylinders were then moistened and mixed thoroughly with 200cc. of a solution containing 0.5 gm. ammonium sulphate, 0.1 gm. potassium phosphate, and 0.01 gm. magnesium sulphate. The mixtures were kept in a moist incubator of 25°C. After two weeks a portion of the mixture was taken from both cylinders and thoroughly dried. 100 grms of the dry mixture were extracted with 100cc. of cold distilled water for 24 hours with frequent shaking ; then filtered, washed, and the filtrate filled to 1 liter. The diphenylamine test at that time was positive with the magnesia mixture but failed with the lime mixture. After 4 weeks again the qualitative test was made and now the limed sample gave a moderate blue coloration but the sample containing magnesia yielded a much more intense reaction.

These comparative colorimetric tests prove that magnesium carbonate favors nitrification much more than calcium carbonate does.

The results of my investigation may be summarized as follows :

1). I. B. Agr. Chem. 1892.

I. Calcium salts retard putrefaction of certain materials.<sup>(1)</sup> On the contrary, magnesium salts favor putrefaction.

II. It is an interesting fact that tricalcium phosphate can be utilized by some putrefying bacteria, proving that in the soil insoluble phosphates can probably be transformed into an available form.

III. Magnesium carbonate favors nitrification much more than calcium carbonate, of which practical use might be made in certain cases.

(1). After these investigations had been finished, a report by Hals appeared in the *Centralblatt für Agriculturchemie* Febr. 1905, which stated that the putrefaction of urine can be prevented by 2% freshly slaked lime. Here however it was a strong base that acted, while our observations relate to neutral salts.

# Correction of a Very Unfavorable Ratio of Lime to Magnesia in a Soil for the Culture of Barley.

BY

**G. DAIKUHARA.**

It has been shown by the experiments of Loew and May,<sup>(1)</sup> Asō, Furuta, Katayama and the author<sup>(2)</sup> that under otherwise favorable conditions a maximum harvest will only be obtained when the amounts of lime and magnesia bear a certain ratio to each other. For most of Gramineae this ratio,  $\frac{\text{CaO}}{\text{MgO}}$  was found to be = 1 or nearly so, while for other plants, especially those which develop more foliage in a given time than the Gramineae, two or more times CaO than MgO is required. Hence it is of interest to determine the available amounts of CaO and MgO in the soil to correct the existing ratio by addition of suitable lime or magnesia-compounds when the difference between these bases is considerable. When this difference does not exceed 0.5 and the lime content is at the same time sufficient, a correction can not be expected to exert an essential influence. Thus some experiments were made by the author with soils showing but small differences in the percentage of these two bases<sup>(3)</sup> namely :

	CaO.	MgO.
Soil from Kinai ... ..	0.44	0.40
.. .. Sendai ... ..	0.96	0.71
.. .. Hokuriku ... ..	0.55	0.79
.. .. Sanyō ... ..	0.42	0.58
.. .. Shikoku ... ..	1.70	1.76
.. .. Sanin ... ..	0.46	0.53
.. .. Tokyo ... ..	1.06	1.40
.. .. Tōkai ... ..	0.44	0.45

(1). Bulletin No. 1. of the Bureau of Plant Industry 1901, Washington.  
 (2). Bulletins of the College of Agriculture, Tokio Imperial University, Vol. IV., V. and VI.  
 (3). These determinations were made with the hot HCl-extract of the fine earth.

The results agreed with the expectation. The yield of naked barley was not essentially altered when the amounts of these bases were rendered equal by adding  $\text{CaCO}_3$  or  $\text{MgCO}_3$ . However a very essential increase of yield is to be expected by correcting the ratio when the differences are much larger. Such a soil occurs e.g. at Ōmagari in the province of Ugo. The analysis showed  $\text{CaO}=0.64\%$   $\text{MgO}=1.91\%$  Therefore, difference  $=1.27$  and the ratio  $\frac{\text{CaO}}{\text{MgO}} = \frac{0.34}{1}$ . This ratio would be very unfavorable for barley and, in accordance with the theory, correction of this ratio, making the amounts equal, yielded a very considerable increase of harvest. This soil was an alluvial humous soil.

The pots used in this experiment contained 10.81 kilo soil. and, in liming, this received 245 gr. precipitated  $\text{CaCO}_3$ . Two pots served in each case. The general manure was :

	Gr. p. pot.	Ratio p. hectar.
Ammonium nitrate ... ..	1.71	342 kilo=112.5 kilo. N.
Sodium phosphate ... ..	1.90	380 „ = 75.0 „ $\text{P}_2\text{O}_5$ .
Potassium carbonate ... ..	0.61	122 „ = 75.0 „ $\text{K}_2\text{O}$ .

In order to attain a proper valuation of that soil, further control tests were made, two pairs of pots not receiving any manure at all, two other pairs no potassa, and two further pairs no nitrogen.

Nine seeds of naked barley (variety *osome*) were sown Nov. 24 [1903] and the young plants, when 10—12 cm. high, reduced to 5 of equal size in all the twenty pots. All conditions were kept as equal as possible.

The average height of the 5 plants in each pot and the average number of stalks were as follows :

Manures applied	Kind of soil	No. of Pots.	Height of Plants		Number of Stalks
			April 20.	May 31.	May 31.
General manure	Original soil	1.	30.6 cm. } <i>Aver.</i> 24.6 cm.	52.8 cm. } <i>Aver.</i> 52.7 cm.	11 } 9
		2.	18.6 „	52.5 „	6
	Limefactor corrected	1.	28.8 „ } 33.3 cm.	57.9 „ } 56.7 cm.	11 } 13
		2.	37.8 „	55.5 „	14

Manures applied	Kind of soil	No. of Pots.	Height of Plants		Number of Stalks			
			April 20.	May 31.	May 31.			
No N	Original soil	1.	27.3 cm.	} 24.9 cm. } <i>Aver.</i>	45.0 cm.	} 45.8 cm. } <i>Aver.</i>	6	} 6
		2.	22.5 "		46.5 "		5	
	Limefactor corrected	1.	36.3 "	} 36.2 cm. }	57.6 "	} 54.3 cm. }	9	} 9
		2.	36.0 "		50.7 "		8	
No K <sub>2</sub> O	Original soil	1.	26.4 "	} 18.3 cm. }	49.2 "	} 38.4 cm. }	9	} 7
		2.	10.2 "		27.6 "		4	
	Limefactor corrected	1.	38.1 "	} 37.8 cm. }	59.6 "	} 63.6 cm. }	14	} 15
		2.	37.5 "		67.5 "		15	
No manure	Original soil	1.	20.4 "	} —	39.6 "	} —	7	} —
		2.	—		—		—	
	Limefactor corrected	1.	26.7 "	} 28.8 cm. }	59.4 "	} 56.0 cm. }	10	} 10
		2.	30.9 "		52.5 "		9	

The plants were photographed before flowering; these photographs, reproduced on Plate I show very plainly the considerable difference of development. The plants were cut on May 31 with the following result.

Manures applied	Kind of soil	No. of Pots.	Grain. Gr.	Chaff. Gr.	Straw. Gr.	Total. Gr.	
General manure	Original soil	1.	8.45	} 6.24 } <i>Aver.</i>	—	} 14.57 } <i>Aver.</i>	} 20.53 } <i>Aver.</i>
		2.	4.22		2.07		
	Limefactor corrected.	1.	12.88	} 14.56 }	4.74	} 20.30 } <i>Aver.</i>	34.92
		2.	16.23		5.27		23.40
No N	Original soil	1.	2.94	} 2.30 }	0.94	} 4.24 } <i>Aver.</i>	8.12
		2.	1.65		0.64		4.74
	Limefactor corrected	1.	13.31	} 12.47 }	4.18	} 17.00 } <i>Aver.</i>	34.49
		2.	11.62		3.91		14.99

Manures applied	Kind of soil	No. of Pots.	Grain. Gr.	Chaff. Gr.	Straw. Gr.	Total Gr.
No K <sub>2</sub> O	Original <sup>1)</sup> soil.	1.	10.44 } <i>Aver.</i>	4.24 } <i>Aver.</i>	14.03 } <i>Aver.</i>	28.71 } <i>Aver.</i>
		2.	— } —	— } —	— } —	— } —
	Limefactor corrected.	1.	17.99 } 18.84	5.42 } 5.66	26.40 } 25.84	49.81 } 50.33
		2.	19.68 } —	5.89 } —	25.27 } —	50.84 } —
No manure	Original <sup>1)</sup> soil.	1.	4.19 } —	1.47 } —	4.59 } —	10.25 } —
		2.	— } —	— } —	— } —	— } —
	Limefactor corrected.	1.	11.81 } 13.68	3.89 } 4.17	14.68 } 15.39	30.36 } 33.22
		2.	15.54 } —	4.44 } —	16.09 } —	36.07 } —

The result shows that on this well manured soil, which contained originally the very unfavorable ratio  $\frac{\text{CaO}}{\text{MgO}} = \frac{0.34}{1}$ , the harvest was doubled by procuring the proper limefactor, and further that the beneficial effect of liming that soil became even more evident when the manuring was one-sided or did not take place at all.<sup>2)</sup> The effect of liming upon the growth of the plant depends, however, not only upon the regulation of the ratio of lime to magnesia but also upon the improvement of the physical and chemical conditions of the soil. To what extent the various actions of liming play a part in the increased production of the plant will be ascertained by future experiments.

(1). In some of the pots the plants were damaged by cold and parasites and were therefore disregarded.

(2). The ratio CaO : MgO in soils is generally disregarded, hence, the results obtained by liming appear often mysterious to the experimenters. Thus Prijanishnikow described recently (Biedermanns Centralblatt 1904, p. 442) some experiments with soils, in which he did not pay attention to the ratio CaO : MgO. The harvest in vetches showed there after liming on one soil an increase, on the other a decrease. Further one soil on addition of 1% CaO yielded an increase in lupines, on another a decrease.

Original soil.



No manure.

N.P.

P.K.

N.P.K.

Lime-factor corrected.

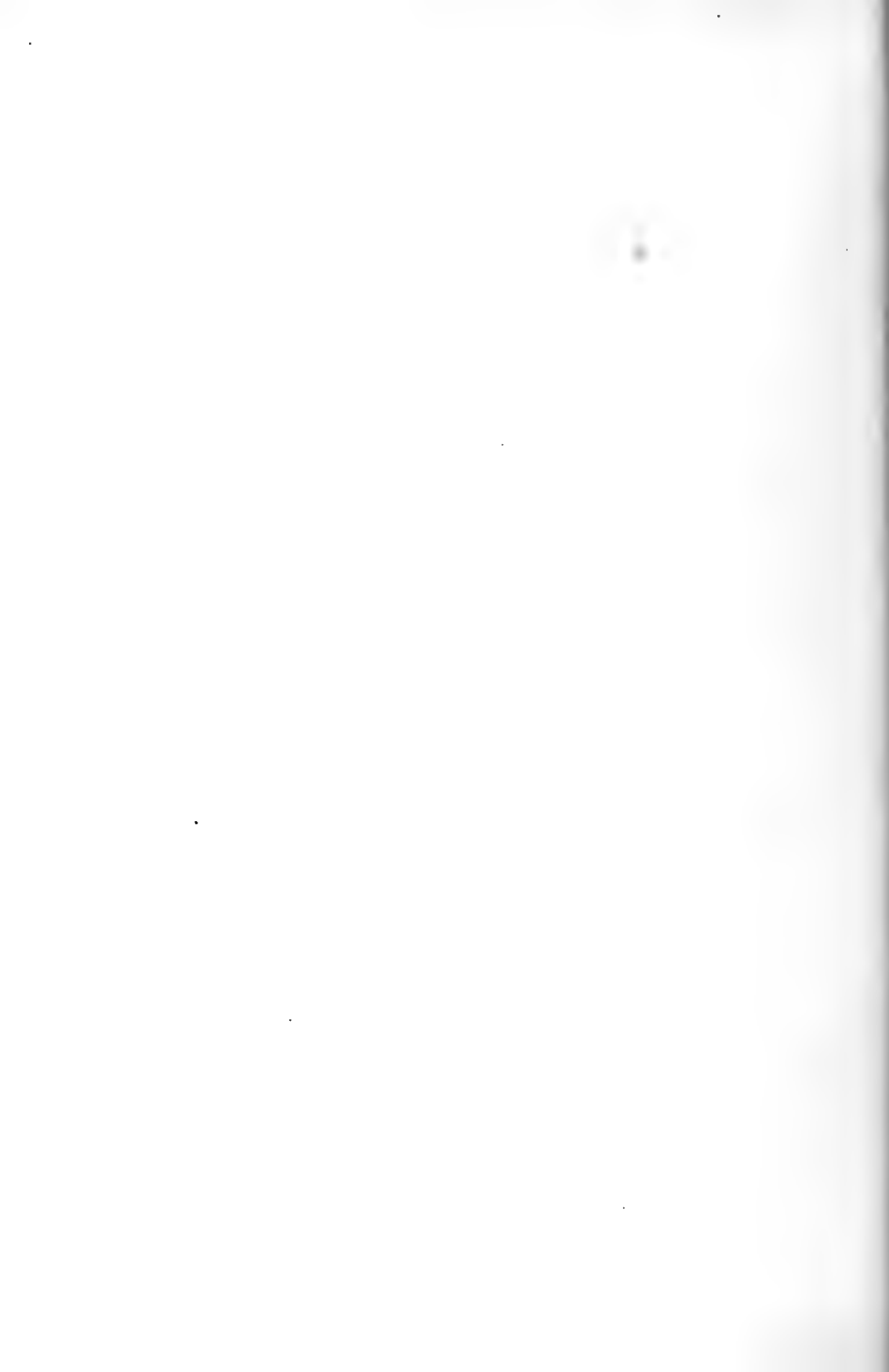


No manure.

N.P.

P.K.

N.P.K.





## On the Lime Factor for the Tobacco Plant.

BY

**G. DAIKUHARA.**

In order to determine the best ratio of lime to magnesia for the tobacco plant, a soil limed in different degrees should be observed. From former experiments with other plants rich in foliage it can hardly be expected that the lime-factor would be much higher than 4. This becomes also probable from the comparisons of the ashes of various kinds of tobacco.

Ash of	CaO	MgO	CaO : MgO
Virginia tobacco . . . . .	31.12	8.58	3.63 : 1
Kentucky „ . . . . .	35.35	9.25	3.78 : 1
Hungarian „ . . . . .	27.10	6.10	4.44 : 1
German „ . . . . .	39.53	9.61	4.11 : 1
In average . . . . .	33.28	8.41	3.96 : 1

The ratio in Massachussets tobaccos was found by Smith also very nearly 4 : 1. Since tobacco is a highly valuable crop in our country it is important to test the soils whether they contain the most beneficial ratio of CaO : MgO.

I have applied in my experiment<sup>1)</sup> three different ratios of CaO to MgO viz.  $\frac{\text{CaO}}{\text{MgO}} : \frac{1}{1} : \frac{2}{1}$  and  $\frac{4}{1}$ .

The original soil contained nearly the same quantities of equally available CaO and MgO, viz. CaO = 0.27% and MgO = 0.25<sup>2)</sup> and the lime applied for procuring the other ratios was air slaked lime which contained CaO 66.88% and MgO 0.75. This lime was mixed with the soil long before the manure was applied in order to have it completely transformed into carbonate.

1) This experiment was performed on our experimental field at Ota in the province of Hitachi.

2) These quantities were determined after Ulbricht's method modified by Katayama, Bulletin of the College of Agriculture, Tokyo, Vol. VI. No. 2.

The manure was supplied at the following ratio :

N as ammonium sulphate ... ..	112.5 kilo. N	p	hectar,
P <sub>2</sub> O <sub>5</sub> as superphosphate ... ..	75.0 "	P <sub>2</sub> O <sub>5</sub>	" " "
K <sub>2</sub> O as potassium carbonate ... ..	112.5 "	K <sub>2</sub> O	" " "

P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O were applied in one dose, June 3, and the N in three doses, June 3, 9 and 17.

51 wooden frames served for the experiment. They were placed in the soil, having an area of 9 square feet, three frames serving for each trial.

On May 28 four young tobacco plants (variety *kokubu*, Mito) were transplanted from the seed bed into the frames.

The plants developed normally and were harvested on August 29 except the sand leaves (Aug. 3). The results obtained from the main frames with different lime-factors are seen from the following tables which show very clearly that the best result was obtained with the lime-factor 4 :

TABLE I.

Lime-factor 1 (Original soil) ... ..	Budding, Aug. 5	Flowering, Aug. 10	Topping, Aug. 13
" 2 ... ..	Jul. 24	" 3	" 10
" 4 ... ..	" 23	" 1	" 10

TABLE II.<sup>1)</sup>

Lime-factor 1 (Original Soil)	Stalk		Leaf			Length of Petiole.
	Length.	Circumference.	Length.	Breadth.	Number.	
146.4 c.m.	9.9 c.m.	42.6 c.m.	30.3 c.m.	24	4.5 c.m.	
" 2	164.1 "	9.9 "	45.0 "	31.5 "	24	4.2 "
" 4	171.0 "	10.2 "	50.1 "	35.1 "	24	4.8 "

TABLE III.<sup>2)</sup>

Limefactor 1 (Original soil)	Leaf and stalk, (fresh).	Leaf, (air dried).	Stump and root, (air dried).
	1004.6 gr.	85.1 gr.	61.1 gr.
" 2	1206.4 "	101.3 "	79.5 "
" 4	1438.5 "	126.2 "	93.5 "

1) Three normally developed plants were selected at the time of harvest and measured.

2) This represents the average number of three parallel experiments.

Further experiments were performed with the soil which was only supplied with partial manures. The observations made during these experiments are contained in the following tables.

TABLE IV.

Manures applied.	Kind of soils.	Budding.		Flowering.		Topping.	
No Manure	Original soil	Aug.	12	Aug.	19	Aug.	23
	Limefactor 4	Jul.	28	"	10	"	10
N, P <sub>2</sub> O <sub>5</sub> , K <sub>2</sub> O	Original soil	Aug.	5	"	10	"	13
	Limefactor 4	Jul.	23	"	1	"	10
N	Original soil	Aug.	3	"	13	"	16
	Limefactor 4	Jul.	24	"	8	"	10
P <sub>2</sub> O <sub>5</sub>	Original soil	Aug.	10	"	17	"	19
	Limefactor 4	Jul.	28	"	9	"	10
K <sub>2</sub> O	Original soil	Aug.	10	"	19	"	23
	Limefactor 4	Jul.	28	"	10	"	13
N, P <sub>2</sub> O <sub>5</sub>	Original soil	Aug.	5	"	10	"	10
	Limefactor 4	Jul.	28	"	5	"	13
N, K <sub>2</sub> O	Original soil	Aug.	2	"	14	"	19
	Limefactor 4	"	1	"	11	"	16
P <sub>2</sub> O <sub>5</sub> , K <sub>2</sub> O	Original soil	"	8	"	16	"	19
	Limefactor 4	Jul.	28	"	10	"	13

The effect of liming upon the growth of the plants was, as seen in Plate II, very remarkable.

TABLE V.<sup>1)</sup>

Manures applied.	Kind of soils.	Stalk		Leaf			Length of Petiole.
		Length.	Circumference.	Length.	Breadth.	Number.	
No manure	Original soil	128.7 c.m.	7.2 c.m.	37.8 c.m.	24.0 c.m.	23	4.2 c.m.
	Limefactor 4	152.6 "	9.0 "	43.8 "	26.7 "	26	5.7 "
N, P <sub>2</sub> O <sub>5</sub> , K <sub>2</sub> O	Original soil	146.4 "	9.9 "	42.6 "	30.3 "	24	4.5 "
	Limefactor 4	171.0 "	10.2 "	50.1 "	35.1 "	24	4.8 "
N	Original soil	138.6 "	8.7 "	40.8 "	28.2 "	23	5.1 "
	Limefactor 4	178.2 "	9.9 "	47.7 "	32.1 "	23	5.1 "
P <sub>2</sub> O <sub>5</sub>	Original soil	126.3 "	7.5 "	34.2 "	23.7 "	27	4.2 "
	Limefactor 4	167.4 "	10.2 "	48.3 "	31.2 "	24	5.4 "
K <sub>2</sub> O	Original soil	127.2 "	7.2 "	35.1 "	23.1 "	27	4.5 "
	Limefactor 4	155.4 "	9.3 "	43.5 "	29.7 "	27	5.4 "
N, P <sub>2</sub> O <sub>5</sub>	Original soil	155.4 "	9.6 "	42.9 "	30.3 "	26	5.1 "
	Limefactor 4	158.4 "	9.8 "	42.9 "	29.7 "	25	4.8 "
N, K <sub>2</sub> O	Original soil	140.7 "	8.7 "	43.5 "	29.1 "	24	5.1 "
	Limefactor 4	143.1 "	8.7 "	42.0 "	27.9 "	24	4.8 "
P <sub>2</sub> O <sub>5</sub> , K <sub>2</sub> O	Original soil	135.0 "	8.1 "	39.3 "	25.8 "	25	4.5 "
	Limefactor 4	165.6 "	9.3 "	43.2 "	27.6 "	27	5.4 "

The plants were harvested also on August 29 with the following results (average of 3 parallel experiments)

1) Three normally developed plants were selected and measured.

TABLE VI.

Manures applied.	Kind of soils.	Weights					
		Total. (in the fresh state)		Leaf. (air dried).		Stump and root, (air dried).	
No manure	Original soil	647.6	gr.	53.7	gr.	30.4	gr.
	Limefactor 4	1211.6	..	88.2	..	75.4	..
N, P <sub>2</sub> O <sub>5</sub> , K <sub>2</sub> O	Original soil	1004.6	..	85.1	..	61.1	..
	Limefactor 4	1438.5	..	106.2	..	93.8	..
N	Original soil	853.2	..	77.7	..	56.3	..
	Limefactor 4	1271.6	..	100.5	..	82.9	..
P <sub>2</sub> O <sub>5</sub>	Original soil	665.3	..	58.1	..	31.9	..
	Limefactor 4	1248.0	..	94.1	..	80.3	..
K <sub>2</sub> O	Original soil	603.8	..	48.9	..	24.8	..
	Limefactor 4	1133.7	..	93.8	..	66.8	..
N, P <sub>2</sub> O <sub>5</sub>	Original soil	1127.3	..	85.2	..	62.3	..
	Limefactor 4	1042.0	..	84.4	..	55.5	.. 1)
N, K <sub>2</sub> O	Original soil	853.9	..	68.3	..	43.5	..
	Limefactor 4	894.8	..	76.9	..	49.1	..
P <sub>2</sub> O <sub>5</sub> , K <sub>2</sub> O	Original soil	748.1	..	67.5	..	36.0	..
	Limefactor 4	1067.3	..	84.8	..	60.0	..

The weights of the different kinds of leaves sorted according to their positions are shown in the following table.

1) In these frames a red spot disease was noticed.

TABLE VII.

Manures applie.d.	Kind of soils.	Weight of Leaves air dried.					Comparison, (original soil = 100).
		Sand Leaves.	Middle Leaves.	Main Leaves.	Tip Leaves.	Total	
No manure	Original soil.	3.8 gr.	9.0 gr.	30.4 gr.	10.5 gr.	53.7 gr.	100
	Limefactor 4.	6.8 ..	18.0 ..	47.3 ..	16.1 ..	88.2 ..	164
N, P <sub>2</sub> O <sub>5</sub> , K <sub>2</sub> O	Original soil.	7.1 ..	16.1 ..	46.5 ..	15.4 ..	85.1 ..	100
	Limefactor 2.	8.6 ..	21.8 ..	57.0 ..	13.9 ..	101.3 ..	119
	Limefactor 4.	9.4 ..	20.3 ..	60.4 ..	16.1 ..	106.2 ..	125
N	Original soil.	5.3 ..	13.1 ..	48.0 ..	11.3 ..	77.7 ..	100
	Limefactor 4.	8.6 ..	17.3 ..	57.0 ..	17.6 ..	100.5 ..	128
P <sub>2</sub> O <sub>5</sub>	Original soil.	4.1 ..	10.1 ..	34.5 ..	9.4 ..	58.1 ..	100
	Limefactor 4.	6.4 ..	19.9 ..	52.5 ..	15.3 ..	94.1 ..	162
K <sub>2</sub> O	Original soil.	3.8 ..	8.3 ..	29.3 ..	7.5 ..	48.9 ..	100
	Limefactor 4.	7.5 ..	18.0 ..	54.0 ..	14.3 ..	93.8 ..	192
N, P <sub>2</sub> O <sub>5</sub>	Original soil.	7.9 ..	15.0 ..	48.4 ..	13.9 ..	85.2 ..	100
	Limefactor 4.	8.6 ..	19.1 ..	42.4 ..	14.3 ..	84.4 ..	99 <sup>1)</sup>
N, K <sub>2</sub> O	Original soil.	5.3 ..	11.6 ..	40.5 ..	10.0 ..	68.3 ..	100
	Limefactor 4.	8.6 ..	15.0 ..	39.8 ..	13.5 ..	76.9 ..	113
P <sub>2</sub> O <sub>5</sub> , K <sub>2</sub> O	Original soil.	4.9 ..	11.6 ..	40.1 ..	10.9 ..	67.5 ..	100
	Limefactor 4.	7.1 ..	15.0 ..	49.9 ..	12.8 ..	84.8 ..	126

The results obtained in all of the experiments show unanimously that the liming of the soil has a good effect upon the growth of the tobacco plant. To what extent the regulation of the ratio of lime to magnesia contributes to the increased yield of the tobacco plant will, as stated above be ascertained by future experiments.

(1) As already mentioned a red spot disease appeared in these frames.

Original soil.



No manure.



N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O.

Lime-factor corrected.



No manure.



N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O.





Original soil.



N.



P.O.

Lime-factor corrected.



N.



P.O.



Original soil.



$K_2O$ .

Lime-factor corrected.



$K_2O$ .



## On the Application of Magnesia in the Form of Magnesium Sulphate for the Needs of the Rice Plant.

13

G. DAIKUHARA.

The question how to provide a soil, very rich in lime and relatively poor in magnesia, with the necessary amount of magnesia is of practical importance. Since there occur no large deposits of magnesite in Japan and further since dolomite contains too much lime for our purpose, there remains as a chief material only the sulphate of magnesia. This salt, however, furnishes the magnesia in a highly available form, while the original lime compounds in the soil are generally not so easily available, hence the quantity of magnesium sulphate ( $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ ) to be applied must be relatively small and carefully regulated in order to provide the plant with the most favorable ratio of CaO and MgO. Let us suppose a given soil contains 1% of lime in form of carbonate, then 1% of magnesia in form of magnesite must be added in order to reach the best ratio for rice or related cereals. But in applying magnesia as a sulphate much less will be required to produce the same beneficial effect, and a further increase would prove very injurious. It is now the question what amount of magnesia as sulphate would be required for a given soil to produce the maximum harvest. Since no suitable soil was at hand, an experiment with sand culture was made.

Quartz sand, after treating with dilute HCl (2%) and careful washing with water, was mixed with 1% of lime as carbonate, while the magnesia was applied as sulphate in the following proportions :

No. of Pot.	CaO : MgO	CaCO <sub>3</sub> added.		MgSO <sub>4</sub> · 7 H <sub>2</sub> O added.	
		Larger pots.	Smaller pots.	Larger pots.	Smaller pots.
1.	5 : 1	80.4 gr.	30.4 gr.	54.96 gr.	20.77 gr.
2.	10 : 1	..	..	27.48 ..	10.39 ..
3.	20 : 1	..	..	13.74 ..	5.19 ..
4.	30 : 1	..	..	9.16 ..	3.46 ..
5.	40 : 1	..	..	6.87 ..	2.60 ..
6.	50 : 1	..	..	5.50 ..	2.08 ..
7.	60 : 1	..	..	4.58 ..	1.73 ..

28 glass pots served for this experiment, half of which contained 4.5 kilo. sand, while the other half held only 1.7 kilo. To the 14 larger pots 2 grms. of sodium nitrate were applied as nitrogenous manure, to the 14 smaller pots the same quantity of nitrogen in the form of ammonium sulphate. To all these pots so much mono-potassium phosphate was applied that the ratio  $N : P_2O_5 = 2 : 1$  was attained.

As potassa manure 2 gr. potassium sulphate served per pot. Traces of ferrous sulphate and some sodium silicate were also added.

9 seeds of rice (variety *sekitori*) were sown June 8, 1904, in the 14 larger pots and afterward the young plants reduced to 5 of equal size for each pot. In the smaller pots five young plants about 30 cm. high of the same variety of rice were planted July 1. All the pots were kept in a glass house.

The height of plants and the number of stalks measured July 26 are seen in the following table :

## I. Manured with sodium nitrate.

No. of Pot	CaO : MgO	Height of plants, cm.	Number of stalks.	Average per pot.		
				Height of plants, cm.	Number of stalks.	
1.	5 : 1	Pot 1.	34.5	5	34.5	5.0
		" 2.	— <sup>1)</sup>			
2.	10 : 1	Pot 1.	54.0	7	51.8	6.5
		" 2.	49.5	6		
3.	20 : 1	Pot 1.	53.1	6	54.6	6.5
		" 2.	56.1	8		
4.	30 : 1	Pot 1.	60.3	7	58.8	6.5
		" 2.	57.3	6		
5.	40 : 1	Pot 1.	51.6	5	53.0	6.5
		" 2.	54.3	8		
6.	50 : 1	Pot 1.	63.9	9	60.3	8.0
		" 2.	56.7	7		
7.	60 : 1	Pot 1.	55.5	6	54.8	7.5
		" 2.	54.0	9		

## II. Manured with ammonium sulphate.

No. of Pot	CaO : MgO	Height of plants, cm.	Number of stalks.	Average per pot.		
				Height of plants, cm.	Number of stalks.	
1.	5 : 1	Pot 1.	24.6	4	25.8	4.0
		" 2.	27.0	4		
2.	10 : 1	Pot 1.	41.1	7	35.9	7.5
		" 2.	36.6	8		

1) Plants in this pot died off in the middle of July.

No. of Pot	CaO : MgO	Height of plants. cm.	Number of stalks.	Average per pot.		
				Height of plants. cm.	Number of stalks.	
3.	20 : 1	Pot 1.	40.2	13	39.6	11.5
		" 2.	39.0	12		
4.	30 : 1	Pot 1.	43.2	8	43.7	8.5
		" 2.	44.1	9		
5.	40 : 1	Pot 1.	43.2	7	42.6	6.5
		" 2.	42.0	6		
6.	50 : 1	Pot 1.	37.8	12	43.1	11.5
		" 2.	48.3	11		
7.	60 : 1	Pot 1.	42.9	8	42.5	8.5
		" 2.	42.5	9		

The difference in the development of the plants became, as seen in Plate III, very marked. On Oct. 22 the plants were cut, except No. 1 which was harvested Oct. 29 and, after becoming air dry, weighed. The stumps and roots were well washed with water, dried and weighed also. The results are shown in the following tables :

#### I. Manured with sodium nitrate.

No. of Pot.	CaO : MgO	Seeds. gr.	Stalks. gr.	Stumps and roots. gr.	Average per pot.				
					Seeds. gr.	Stalks. gr.	Stumps and roots. gr.	Total. gr.	
1.	5 : 1	Pot 1.	2.0	4.4	1.1	2.0	4.4	1.1	6.9
		" 2.							
2.	10 : 1	Pot 1.	4.8	6.2	4.2	4.1	5.0	2.1	12.1
		" 2.	3.3	5.6					
3.	20 : 1	Pot 1.	3.5	5.6	4.0	4.2	6.1	2.3	12.6
		" 2.	4.8	6.5					



No. of Pot.	CaO : MgO	Seeds. gr.	Stalks. gr.	Stumps and roots. gr.	Average per pot.				
					Seeds. gr.	Stalks. gr.	Stumps and roots. gr.	Total. gr.	
4.	30 : 1	Pot 1.	5.3	8.0	7.0	5.1	7.1	3.5	15.7
		.. 2.	4.9	6.1					
5.	40 : 1	Pot 1.	3.3	4.7	5.0	4.1	5.6	2.5	12.2
		.. 2.	4.9	6.4					
6.	50 : 1	Pot 1.	5.5	7.2	6.0	5.4	7.1	3.0	15.5
		.. 2.	5.2	6.9					
7.	60 : 1	Pot 1.	5.1	6.7	5.4	5.1	6.7	2.7	14.5
		.. 2.	5.1	6.7					

## II. Manured with ammonium sulphate.

No. of Pot.	CaO : MgO	Seeds. gr.	Stalks. gr.	Stumps and roots. gr.	Average per pot.				
					Seeds. gr.	Stalks. gr.	Stumps and roots. gr.	Total gr.	
1.	5 : 1	Pot 1.	0.9	5.7	1.9	1.4	7.2	1.0	9.6
		.. 2.	1.0	8.7					
2.	10 : 1	Pot 1.	8.7	12.7	6.2	8.2	12.3	3.1	24.2
		.. 2.	7.7	13.1					
3.	20 : 1	Pot 1.	15.2	16.5	7.1	14.3	16.1	3.6	34.0
		.. 2.	13.4	15.6					
4.	30 : 1	Pot 1.	13.8	17.8	10.6	14.2	18.2	5.3	37.7
		.. 2.	14.6	18.5					
5.	40 : 1	Pot 1.	13.1	17.3	8.4	12.5	17.0	4.2	33.7
		.. 2.	11.9	16.7					
6.	50 : 1	Pot 1.	12.5	16.7	8.7	13.0	17.6	4.4	35.0
		.. 2.	13.5	18.5					
7.	60 : 1	Pot 1.	13.0	15.4	7.6	12.9	14.6	3.8	29.3
		.. 2.	8.8	13.8					

These tables show that in the presence of lime as carbonate the necessary amount of magnesia when applied as crystallized sulphate for paddy rice in sand culture is so small that the best ratio CaO : MgO becomes 30 : 1, while in the form of natural carbonates the best ratio would be 1 : 1 as Aso<sup>1)</sup> had ascertained. This conclusion will hold good also for various sandy soils, while for clayey soils the best ratio  $\frac{\text{CaO as carbonate}}{\text{MgO as sulphate}}$  will differ.<sup>2)</sup>

#### An Additional Experiment.

A trial was made with the same sand in smaller pots which received nitrogen as ammonium nitrate, the ratio CaO : MgO being 30 : 1. The manures and treatment were quite the same as in the former experiments. The results obtained are shown in the following table :

Manured with ammonium nitrate.

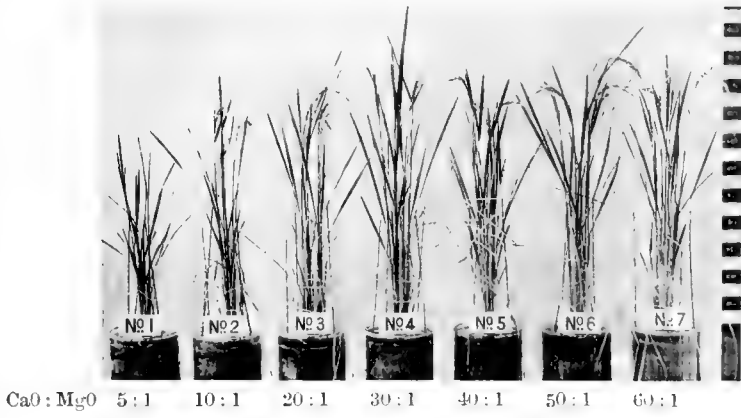
CaO : MgO	Seeds. gr.	Stalks. gr.	Stumps and roots. gr.	Average per pot.			Total. gr.
				Seeds. gr.	Stalks. gr.	Stumps and roots. gr.	
30 : 1	Pot. 1. 11.2	12.6	} 7.4	11.4	13.2	3.7	28.3
	" 2. 11.7	13.8					

For comparison we add here the average figures for the pots with the ratio CaO : MgO = 30 : 1 from the former experiments in which the nitrogen was applied in the form of  $(\text{NH}_4)_2\text{SO}_4$  and  $\text{NaNO}_3$  in the following table :

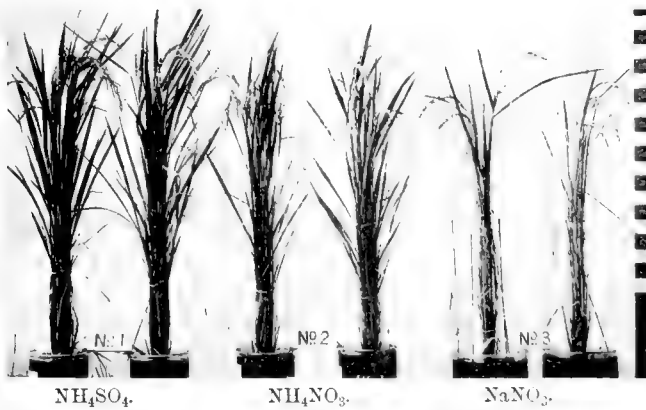
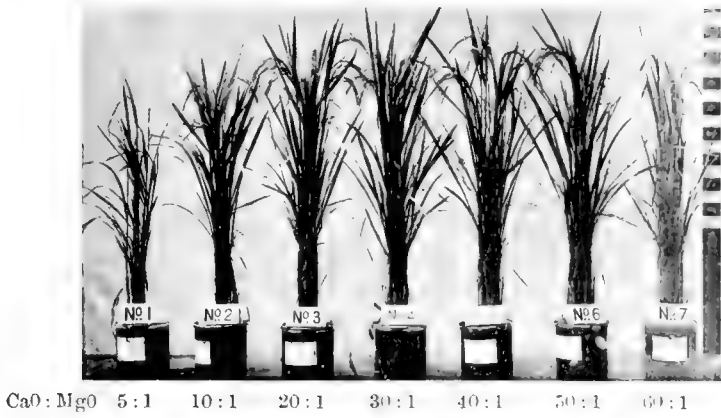
1) Bulletin of the College of Agriculture, Tokio Imperial University, Vol. VI, No. 2.

2) Compare the following article by T. Nakamura

Paddy rice with sodium nitrate.



Paddy rice with ammonium sulphate.





No. of Pot.	Kind of Manures.	Seeds. gr.	Stalks. gr.	Stumps and roots. gr.	Total.	
					gr.	ratio.
1.	$(\text{NH}_4)_2 \text{SO}_4$	14.2	18.2	5.3	37.7	100
2.	$\text{NH}_4 \text{NO}_3$	11.4	13.2	3.7	28.3	75
3.	$\text{NaNO}_3$	5.1	7.1	3.5	15.7	42

This result shows that the application of nitrogen as sodium nitrate is not favorable for rice plants, the relative value of which to ammoniacal nitrogen being 40 : 100. This agrees very well with the result recently obtained by M. Nagaoka.<sup>1)</sup> The relative manurial value of ammonium nitrate stands, as seen in the above table, between that of sodium nitrate and ammonium sulphate.

1) Bulletin of the College of Agriculture, Tokio Imperial University, Vol. VI. No. 3.

# On the Improvement of a Soil Relatively Deficient in Magnesia.

BY

T. Nakamura.

Near the field of our branch experimental station in Kyūshyū lies a large area of land consisting of a soil very fine in texture but very light for farm implements. The following table gives the information on the composition of the soil

In 100 parts of the air dried fine soil,

Hygroscopic moisture...	11.85
Loss on ignition ...	19.00
Humus ...	2.31
Water lost on ignition ...	16.69
Nitrogen ...	0.22
Mineral matter insoluble in hot HCl of 1.15 Sp. Gr. ...	53.24

Mineral matters soluble in hot HCl of 1.15 Sp. Gr.

$Al_2O_3$ ...	9.60
$Fe_2O_3$ ...	7.73
$Mn_2O_4^{(1)}$ ...	—
CaO ...	1.76
MgO ...	0.11
$K_2O$ ...	0.1
$Na_2O$ ...	0.84
$P_2O_5$ ...	0.09
SO ...	0.14
SiO ...	.1
CO ...	.1
C ...	.2
$SiO_2$ soluble in $Na_2CO_3$ ...	2.35

The mechanical analysis of the original soil gave the following result :

(1) Manganese was present, but not determined.

Over 0.5 m.m. ... ..	0.09 %
0.5 — 0.25 „ ... ..	4.25 „
0.25 — 0.1 „ ... ..	25.02 „
0.1 — 0.05 „ ... ..	16.32 „
0.05 — 0.01 „ ... ..	11.32 „
below 0.01 „ ... ..	43.00 „

First of all, we see that this soil is characterized by a large quantity of lime in comparison with magnesia. It is also remarkable that the soil, on warming with some HCl, is converted into a gelatinous mass, owing to the separation of much silica. A further characteristic of this soil is a high percentage of silica soluble in sodium carbonate, and of the combined water liberated by ignition. These facts show clearly that this soil consists, to a great deal, of hydrous silicates. Further the exceedingly small quantity of CO<sub>2</sub> compared with CaO indicates that the latter exists chiefly in the form of silicate.

Judging from the amount of magnesia, we see that this soil would certainly contain a sufficient quantity of this base for the normal growth of various kinds of plants, but the quantity of lime is about seventeen times larger than that of magnesia, and if the same ratio of CaO and MgO contained in the soil is absorbed by the plants, they would not grow normally, since the great excess of lime interferes with the function of the magnesia<sup>(1)</sup>. The proper way to correct the unfavorable ratio of lime and magnesia of this soil, for the growth of Gramineae, would be to add so much magnesia in the form of insoluble hydrous silicate or of powdered magnesite that the ratio of lime to magnesia becomes 1 : 1, for the availability of the magnesia would then agree or nearly so with that of lime. But since magnesite is found only very rarely in this country I intended to use soluble magnesium sulphate, which must of course be applied in much smaller quantity than magnesite.

In order to determine the best quantity of magnesium sulphate to be applied to the soil the following experiments were made

(1) Compare the theory of O. Löw in the Bulletin of the College of Agriculture, Imp. University, Tokyo, Vol. V. No. 4.

Twelve zinc pots, each measuring 25 c.m. in diameter and 37 c.m. in height were filled with 9.653 kilog. of the air dried soil, which was taken from a bare field near the experimental station. The soil in each pot contained, therefore, 169.98 g. CaO and 10.10 g. MgO. The excess of CaO over MgO amounted to 159.98 g. (round number 160 g.) In order to increase the amount of magnesia in the soil, the following quantities of  $\text{MgSO}_4 + 7\text{Aq.}$  were applied :

No. of Pots.		Amounts of magnesium sulphate applied per pot.
1 & 7.		Control
2 & 8.		$160 \times \frac{1}{25}$ g. MgO = 39.36 g. $\text{MgSO}_4 + 7\text{Aq.}$
3 & 9.		" $\times \frac{2}{25}$ " " = 78.72 g. "
4 & 10.		" $\times \frac{3}{25}$ " " = 118.08 g. "
5 & 11.		" $\times \frac{4}{25}$ " " = 157.44 g. "
6 & 12.		" $\times \frac{5}{25}$ " " = 196.80 g. "

The experiments were made in duplicate. On Nov. 17 (1903) the magnesium sulphate was well mixed with the soil in the pulverized state. On the succeeding days, 0.5 g.  $\text{P}_2\text{O}_5$  (as disodium phosphate), then 0.25 g.  $\text{K}_2\text{O}$  (as carbonate) and then 0.5 g. N. (as ammonium chloride) were given per pot. On Nov. 23 barley seeds were sown (9 grains per pot)

The observations made during the experiment and the results obtained are given in the following table :



No. of Pots.	1 and 7	2 and 8	3 and 9	4 and 10	5 and 11	6 and 12
Mg SO <sub>4</sub> + 7 Aq applied, g.	0.00	39.36	78.72	118.08	157.44	196.80
Time of germination.	Dec. 4.	Dec. 5.	Dec. 6.	Dec. 6.	Dec. 11.	Dec. 19.
„ „ flowering	May 14.	May 4.	Apr. 15.	May 5.	May 18.	Jun. 7.
„ „ maturity	Jun. 3.	May 25.	May 25.	May 25.	Jun. 9.	Jun. 9.
Number of days from sowing to maturity.	193.	184.	184.	184.	199.	201
Length of the highest stalk in cm.	105	99	100	98	65	56
Number of stalks with perfect ears.	11	19	22	21	7	1
Number of stalks with imperfect ears.	10	6	3	5	4	1
Number of stalks without ears.	0	0	0	0	1	2
Total number of stalks.	21	25	25	26	12	4
Straw, g.	41.63	45.40	50.42	49.52	25.98	10.65
Full seeds, g.	13.10	16.55	22.10	19.13	4.78	0.58
Empty seeds, g.	1.05	0.95	0.88	0.85	0.77	0.37
Total, g.	55.78	63.90	73.40	69.50	31.53	11.60
Proportion of grain, control = 100.	100.	123	169	146	37	4

As seen from the above table the best result was obtained when 78.72 g. MgSO<sub>4</sub>+7Aq. were applied to the pot. The plants in this pot flowered 28 days earlier and matured 9 days sooner than those of the control pot, and the plus yield amounted to 69%. If, however, magnesia was applied in excess, it exerted a very injurious action on the growth of the plant. On the contrary, the application of a small quantity of magnesium sulphate (0.59 g. as Mg O per pot=100 kilog. per hectare) remained, as preliminary experiments showed, without effect.

These results show decidedly that the addition of a certain quantity of magnesia acts very beneficially upon the growth of the plant when the soil

contains a large excess of lime over magnesia<sup>(1)</sup> and furnish at the same time a further proof of the inference that "a maximum yield depends—other things being equal—also upon a certain ratio of lime to magnesia which enters into the plant."

Further, we see from the above results, that the most favorable ratio of lime and magnesia is 7 : 1, provided, the magnesia is applied in the form of sulphate. This result holds good in the case of clayey and perhaps also of certain humus soils, but surely not of sandy soils, to which a much smaller quantity of this sulphate must be applied.

Since the best ratio of lime to magnesia for the growth of cereals was found to be 1 : 1 when magnesia was applied in the form of magnesite, it would have required 333 g magnesite per pot in order to attain the above ratio. As the best result was, however, obtained when 78.72 g. magnesium sulphate were applied per pot, we may conclude that the relative value or agronomical equivalent of magnesium sulphate to magnesite is here nearly 23 : 100.

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(1) Larbaletrier and Malpeau (Ann. agr. 1896) obtained in France a very favorable result in applying 300 kilog. magnesium sulphate per ha., but in this case also the lime content exceeded the magnesia content considerably, otherwise the result would certainly have been unfavorable.

# On the Stimulating Action of Potassium Iodide upon Sesamum and Spinach.

BY

S. UCHIYAMA.

The stimulating action of very small doses of potassium iodide on rice, oats, radishes and peas was observed by S. Suzuki and Aso.<sup>1)</sup> It was of interest to extend such observations also upon other plants. For this purpose, we selected *sesamum* and *spinach*.

## I. A Pot Experiment with Sesamum.

The experiment was carried out with six zinc pots of a diameter of 30.4 c.m. ( $\frac{1}{137500}$  ha.). On June 26, 1904 each pot received 15 kilo. air dry soil from an unmanured plot of our experimental field, and was then manured with 225 g. farmyard manure and 15 g. bone dust. After two days, the seeds (20 for each pot) were sown, and on July 20, the young shoots were reduced per pot to five of about equal size.

Potassium iodide was fractionally applied in high dilution in three different periods i.e. July 20, 28, and August 5.

At the end of July, some decisive differences could be observed, the treated plants showing more growth and a darker green color.

The crop was harvested on Sept. 22, and weighed in the air dry state. The following table shows the result thus obtained (average of two parallel experiments)

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1) Bulletin of the College of Agriculture, Tokio Imperial University, Vol. V, No. 4. and Vol. VI, No. 2.

KI in gram.		Average yield per pot in gram.				Comparative yield of full grains
per pot	per ha.	Full-grains	Empty grains	Stems and husks	Total	
0	0	8.50	0.10	19.60	28.20	100
0.0009	123.7	9.85	0.15	25.65	35.65	116
0.009	1237.0	10.65	0.25	25.95	36.85	125

## II. A Field Experiment with Sesamum.

A field experiment was also carried out with *Sesamum*. On June 26, 1904 two plots, each having an area of 59.5 square metres were manured at the rate of 3005 kilo. farmyard manure and 112.7 kilo. each of common superphosphate and straw ash per ha. . The seeds were then sown and the young shoots were finally singled out each at a distance of 10 cm. in three fractions i.e. July 13, 20, 27. To one plot, potassium iodide was fractionally applied at the rate of 25 g. per ha. as follows :

I	July	20	0.015 g. KI dissolved in 54 litres
II	August	2	0.045 g. " " " " "
III	"	9	0.090 g. " " " " "

Soon after the second application of potassium iodide, the treated plants showed a more luxuriant growth. The crop was harvested on Sept. 17 and weighed in the air dry state in kilo. as follows :

	Full grains	Empty grains	Stems and husks	Total	Comparative yield of full grains
Control plants ... ..	3.494	0.071	14.635	18.200	100
Treated " ... ..	4.320	0.101	17.607	22.911	124

## III. A Pot Experiment with Spinach.

The experiment was carried out with six zinc pots of a diameter of 25 cm. ( $\frac{1}{20,000}$  ha) On July 23, 1904 each pot received 16 kilo. air dry soil from an

unmanured plot of our experimental field and was then manured with 150 g. compost and 10 g. bone dust. The seeds (20 for each pot) were sown on August 15, and three weeks later the young shoots were reduced (per pot) to six of about equal size.

Potassium iodide was fractionally applied in high dilution in three periods i.e. Sept. 15, Oct 7 and 15. In the beginning of October, some decisive difference was observed, the treated plants showing better development. The crop was harvested on Oct. 28, and weighed in the fresh state. The following table shows the results thus obtained (average of two parallel experiments).

KI in gram.		Average yield per pot in gram.	Comparative yield
per pot	per ha.		
0	0	22.9	100
0.0006	120.	28.9	126
0.006	1200.	25.9	112

From the results of all these experiments we see that potassium iodide when given in small doses, exerts a stimulating action upon sesamum and spinach. This fact is so far of practical importance, as our farmers on the sea-coast are used to employ as manure sea-weeds which contain more or less potassium iodide.



# Bacillus Nicotianae, Sp. nov; die Ursache der Tabakwelk- krankheit oder Schwarzbeinigkeit in Japan.

VON

Y. UYEDA.

In Japan ist eine Tabakkrankheit sehr verbreitet, die unter dem Namen "*Tachigarc-byo*" (Stengelfäule), "*Kuromushi*" (Schwarzbeinigkeit) oder "*Ichobyo*" (Welkkrankheit) bereits vor vielen Jahren bekannt war. In 1899 wurde diese Krankheit auf dem Tabakversuchsfelde in der Provinz Sagami ebenfalls beobachtet und um dieselbe Zeit, sammelte ich kranke Tabakpflanzen aus den Provinzen Shinano und Hitachi. Wahrscheinlich war diese Krankheit schon vor ungefähr 20-30 Jahren verbreitet, weil sie schon in "*Ensoroku*" (einem japanischen Buch über den Tabakbau, publiziert 1881) beschrieben ist, wenn auch wissenschaftliche Beobachtungen darüber gänzlich fehlen. Vor 4 Jahren hat T. Kugahara (in der Versuchsstation der Hukushima-Ken) Bekämpfungsmethoden dieser Krankheit publiziert. Zur ungefähr gleichen Zeit hat Dr. S. Hori, Mykolog in der hiesigen Versuchs-Station eine Serie von Versuchen über die Bekämpfung dieser Krankheit in der Provinz Hitachi gemacht, wo sie sehr verbreitet ist. Beide Forscher machten jedoch keine ausführliche Mitteilungen über die Ursachen dieser Krankheit. Ferner hatte der Direktor Prof. Y. Kozai der Versuchsstation in Nishigahara eine Art von Bakterien isoliert, welche er für die Ursache der Tabakswelkkrankheit hielt.

Meine Untersuchungen über diese Krankheit begannen vor fast 5 Jahren (1899) und es gelang mir, ein Bakterium zu isolieren, welches mit der von Prof. Kozai aus kranken Tabakpflanzen aus Hukushima isolierten Art identisch ist.

Der betreffende Organismus ähnelt etwas dem *Bacillus Solanacearum*,

Erwin F. Smith,<sup>1)</sup> aber er ist nicht identisch, daher schlage ich einen neuen Namen, *Bacillus Nicotianae*, vor, dessen kurze Diagnose schon publiziert wurde.<sup>2)</sup> Obgleich die Symptome der Tabakwelkkrankheit denjenigen der Eierpflanzen- oder Tomaten-Welkkrankheit sehr ähnlich sind, welche durch *Bacillus solanacearum* verursacht wird, unterscheiden sich doch beide Bakterien in Beziehungen sowohl der physiologischen und morphologischen Eigenschaften als auch ihrer Infektionsfähigkeit. In Folgendem will ich eine Beschreibung dieser Tabakwelkkrankheit, der Ursache, sowie einiger Bekämpfungsmethoden geben, welche in den vergangenen 4 Jahren im hiesigen Laboratorium zur Anwendung gekommen sind.

#### SYMPTOME DER KRANKHEIT.

Die Tabakwelkkrankheit kommt sowohl an jungen wie auch an ausgewachsenen Individuen vor, und zwar während der Monate Juni bis September in verschiedenen Gegenden in Japan. Die Krankheit macht sich zuerst durch ein plötzliches Verwelken bemerklich, ein Gelblichwerden des Blattes folgt, hierauf wird der Stengel schwärz und schliesslich werden die ganzen Wurzeln zerstört. Betreffend der Infektion der Tabakpflanze durch *Bacillus Nicotianae* scheinen mir drei Möglichkeiten vorhanden zu sein, nämlich sie kann durch die Wurzelhaare sowie Hauptwurzel, zweitens durch die Spaltöffnungen des Blattes und drittens durch die beim Köpfen und Geizen verursachten Wunden stattfinden. Wenn die Säfte aus den kranken Pflanzen oder eine Reinkultur von *Bacillus Nicotianae* auf gesunde Tabakblätter übertragen werden, beginnen schon binnen 1–2 Wochen die Blätter sich zu schwärzen und braune Flecken zu produciren. Die Hauptnerven des Blattes werden zunächst ausgehöhlt und dann zerstört. Die Infektionsversuche wurden an jungen und älteren Tabakpflanzen im Versuchsstationsfelde in Nishigahara ausgeführt. Auf den älteren Blättern erscheinen zuweilen wellenförmige schwarze Flecke entlang den Blattnerven, welche durch die in die Spaltöffnungen eingedrungenen Bacillen verursacht sind. Da die Infektion

1) U. S. Depart. of Agr. Bul. No. 12. (1896)

2) Centbl. f. Bakt. 2 Abt. B.I. 13. S. 320.



oft durch die Wurzeln stattfindet, folgt, dass die Bacillen in der Erde perennieren. So können die zuerst sichtbaren Symptome der Krankheit mit denen der Eierpflanzen- oder Tomaten-Welkkrankheit verglichen werden.<sup>1)</sup> Wenn wir den kranken Tabakstengel anschneiden, dann scheidet sich aus den Gefässbündeln eine grosse Menge einer Bakterien enthaltenden Flüssigkeit aus, die etwas alkalisch reagiert. Im Lauf der fortschreitenden Krankheit wird das Rindengewebe des Stengels beträchtlich contrahirt, während zugleich schwarze Linien auf der Oberfläche des kranken Stengels erscheinen. Rinde und Parenchymgewebe der kranken Wurzeln trennen sich voneinander, und zugleich wird das letztere zu einer Anzahl von groben Fasern. Diese Erscheinung kann mit blossen Augen leicht erkannt werden. Der ausgeflossene Saft, sowie die Gefässbündel, Wurzeln, und Blätter der kranken Pflanzen, lassen leicht die im Zellsaft schwimmenden Bacillen erkennen. Diese Krankheit verursacht grossen Schaden durch ihre ungemein schnelle Verbreitung während der Regenzeit. Die hohe Sommertemperatur trägt ebenfalls sehr zur Verbreitung der Krankheit bei.

Im Stengel sowie im Blatte sind die Bacillen zuerst nur in den Gefässbündeln aufzufinden. Daher schwärzen sich zunächst die Nerven und dann erst unterliegt das parenchymatische Gewebe. Wenn man erst kürzlich krank gewordenen Stengel oder Blattstiele anschneidet, sieht man nur lokale Schwärzung des Gefässbündels, während das übrige Gewebe noch gänzlich gesund erscheint.

#### ANATOMISCHE VERÄNDERUNGEN DER WIRTSPFLANZE.

Wenn wir einen kranken Stengel anschneiden, fällt uns zuerst die Bräunung oder Schwärzung des Gewebes auf, und zwar besonders des Holzgewebes, welches einen schwarzen runden Kreis erkennen lässt. In den ersten Stadien der Krankheit ist nur eine Seite des Stengels schwarz. Häufig lässt er die pathogenen Veränderungen nur nach dem Anschneiden

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1). A. a. O.

erkennen, da er erst nach der Berührung mit der Luft schwarz wird und zwar durch den nun stattfindenden Oxydationsvorgang.

Die Krankheit verbreitet sich allmählich aus dem Holzgewebe nach zwei Richtungen, nämlich nach dem Markgewebe sowie nach dem Rindengewebe hin. Die mikroskopischen Beobachtungen lehren uns, dass das Rindenparenchyma stark zerstört wird; Zellsaft, Stärke, Chlorophyll, Zellkern und der übrige Zellinhalt verschwinden; allein die sclerenchymatischen Zellen scheinen nicht so leicht geschädigt zu werden. Ebenso ist dieses beim parenchymatischen Theile des Gefässbündels der Fall, in welchem auch der Zellinhalt allmählich verschwindet. Aus Taf. VI. Fig. 9 kann man erkennen, dass die Bacillen zuerst den Zellkern und dann die ganze Zelle zur Desorganisation bringen. Zuweilen findet man eine Korkschicht zwischen den gesunden und erkrankten Gewebe. Wenn die erkrankten Pflanzen, aus irgend einem Grunde nicht sofort unterliegen, so bilden sie Blätter von anormaler Gestalt aus. Häufig kommen in dem kranken Stengel, schmale Höhlungen vor, die mit einer grossen Menge von Bacillen erfüllt sind. Im erkrankten Blatt findet man oft die Bacillen in den Blatthaaren schwärmen. Wenn das Wurzelsystem geschädigt wird, so ist das erste Zeichen der Abtrennung des Basttheiles von Holzgewebe. Obgleich der Holzteil des Gefässbündels weit länger den Angriffen dieser Bacillen widersteht als das parenchymatische Gewebe der Rinde, so wird schliesslich doch das ganze Gewebe zerstört. Diese Zersetzung des Gewebes wird vielleicht durch ein Enzym verursacht, welches durch Bacillen ausgeschieden wird. Auf diese Enzymbildung will ich im nächsten Kapitel zurückkommen. Taf. VI. Fig. 7 zeigt die Zersetzung des erkrankten Gewebes, besonders des parenchymatischen Gewebes im Gefässbündel. Auch erkennt man dort die mikroskopischen Veränderungen, welche an dem Markgewebe des Stengels aufgetreten sind. Wenn man die reingezüchteten Bacillen auf eine Gewebeschicht überträgt, so wird man bereits binnen einigen Tagen die Schwärzung erkennen und dann erfolgt bald die Trennung dieses Gewebes in die einzelnen Zellen. Oft werden die Blattnerven der kranken Pflanze ausgehöhlt, dann werden die daran angrenzenden Parenchymzellen und auch nicht selten die Schraubengefässe zerstört.

## BESCHREIBUNG DER ORGANISMEN.

### (A.) Morphologisches.

**Form und Grösse.** *B. Nicotianae* ist 1-1,2  $\mu$ . lang und 0,5-0,7  $\mu$ . dick. Die beiden Enden des Stäbchens sind ziemlich rund, weder spitzig noch eckig; im Wirtsgewebe oft isolirt, aber zuweilen zu zweien verbunden. Bei der Kultur während zwei oder drei Monate bilden sie selten eine kettenförmige Kolonie. Die Grösse des Bacillus variirt mit den Ernährungsverhältnissen z.B. in Bouillon werden die Stäbchen etwas länger als in Agar.

**Färbung.** Der Tabakswelkbacillus, sei er auf verschiedenen Nährsubstraten kultivirt, kann durch basischen Anilin-Farbstoff leicht gefärbt werden, besonders durch die Ziel'sche Lösung (Karbolfuchsin oder Gentianviolett); die Färbung mit Bismarckbraun gelang nicht so gut. Durch die Gram'sche Methode gefärbt erscheinen die Bacillen schwach schwarzblau oder rot.

**Kapseln.** In einer älteren Agarkultur des Bacillus *Nicotianae* kommen mehrere Kapseln zum Vorschein. Man kann das Schleimigwerden der Bacillen als ein Anfangsstadium der Kapselbildung betrachten. Durch die Färbung mit Karbolfuchsin kann man leicht etwaige Kapseln sichtbar machen. Auch Friedländer'sche Methode gibt gute Resultate. Nach etwa 2 Monaten Kultur in Agar bei Zimmertemperatur (August) bildet sich häufig eine schleimige Masse. Diese Masse ist ohne Zweifel entweder aus vielen Kapseln oder aus gelatinösen Substanzen der Bacillen zusammengesetzt.

**Geisseln.** Der Bacillus zeigt lebhaft vibrioartige oder wellenförmige Bewegungen. Er ist mit peritrichen Geisseln versehen. Für Geisselfärbung diente mir eine kleine Menge von einer 15 Stunden alten Agarkultur, welche ich in Wasser auf Deckgläschen brachte, auf der Flamme unter Zufügen des Löffler'schen Beizmittels (sauer mit verdünnter Schwefelsäure) während einiger Minuten erwärmte und alsdann mit Wasser abspülte. Nach Waschen mit absolutem Alkohol färbte ich mit Anilinwasser-Gentianviolett, spülte mit Wasser ab und beobachtete. Die peritrichen Geisseln wurden dann sichtbar. Es scheint mir, dass in vielen Fällen Bacillus *Nicotianae* 4-8 Geisseln besitzt, welche 3-4 mal länger

sind als der Bacillus selbst. Die Färbung geschah auch nach van Ermen-gem'scher Methode. Ich liess eine geringe Menge von Agarkultur auf Deckgläsern vertrocknen, behandelte sie einige Minuten in der Wärme, mit einer Mischung von einem Teil 2 %iger Osmiumsäure mit zwei Teilen 10-25 %iger Tanninlösung, welcher 4-5 Tropfen Eisessig auf 100 ccm zugesetzt worden waren, spülte mit Wasser, dann mit Alkohol ab, behandelte mit einer Silbernitratlösung (2 %) während weniger Sekunden, und legte sie dann in's Reduktionsbad, welches aus 13 g. Gallussäure, 3 g. Gerbsäure, 100 g. Natronacetat, 350 g. Wasser bestand, dann wieder in Silbernitrat. Nach Wiederabspülen mit Wasser liess ich das Präparat trocknen.

**Sporen.** Auf festem Nährsubstrat oder in nährstoffarmen Lösungen werden die Sporen nach etwa einem Monat gebildet. Die Sporenbildung dieser Bacillen ist wichtig, nicht nur in wissenschaftlicher, sondern auch in praktischer Hinsicht, weil sie wahrscheinlich in den Tabaksfeldern während der kalten Winterzeit in den nördlichen Provinzen Japans andauern dürfte. Sehr oft findet man Sporen in Agarstrichkulturen (Zimmertemperatur, September), welche 3 Monate alt sind; es ist jedoch zu bemerken, dass in dem unteren Theil einer Strichkultur, wo man häufig schleimige Massen wahrnimmt, die Sporenbildung nicht eintritt.

### (B). Physiologisches.

**Ecuillon.** In neutraler Rindfleischpepton-Lösung, bei Zimmertemperatur in Juli, wächst *BACILLUS NICOTIANAE* sehr schnell und üppig, so dass binnen eines Tages die Flüssigkeit trüb und bereits nach 3 Tagen eine dünne Haut gebildet ist. Bei starkem Schütteln der Kulturgefässe bricht die Haut, welche in ihren dicken blauen und dünneren weissen Teilchen einen mosaikartigen Anblick darbietet. Nach einer Woche nimmt die Färbung der Nährlösung zu, und es bildet sich ein grauweisser Bodensatz aus Bakterienmassen. Allmählich wird die Haut grau und ziemlich körnig und nach etwa einem Monat sieht man oft einen schwarzen Ring um dieselbe. Der Bodensatz ist gewöhnlich nicht sehr schleimig. Die Nährlösung wird bisweilen braun gefärbt. Bei Kultur in einem Erlenmeyer'schen Kolben mit Bouillon,

nimmt, nach zwei Wochen bei Zimmertemperatur im Oktober, die Lösung eine tief graubraune Färbung an. Traubenzucker-Bouillon ist für das Wachstum dieser Organismen sehr günstig. In älteren Bouillonkulturen, findet man eine grosse Menge von rhomboidalen Krystallen, welche vielleicht aus Ammoniummagnesiumphosphat bestehen.

**Gelatineplattenkulturen.** 1-2 Tage nach Infektion im Gelatinenährboden erscheinen kleine Kolonien im Innern sowohl als auf der Oberfläche. Bei etwa 50 facher Vergrösserung stellen die Oberflächenkolonien als rundliche, hellgraue, nach der Mitte zu dunkler werdende etwas körnige Scheiben mit mehr oder weniger unregelmässigen Rand dar. Nach 4-5 Tagen, verflüssigen die älteren Oberflächenkolonien allmählich die Gelatine in centrifugaler Richtung, und alsdann sieht man in dem verflüssigten Theil ein Sediment von Bakterien. Nach 6 Tagen werden die Kolonien etwas becherförmig. Nach einer Woche behalten die in der verflüssigten Gelatine schwimmenden Kolonien noch ihre ursprüngliche Form bei, ohne zu brechen. Die in der Tiefe liegenden Kolonien weisen eine ellipsoidische Form auf, und bereits binnen wenigen Tagen verschmelzen sie zu einer sehr kleinen Masse.

**Gelatinestrichkulturen.** Nach etwa 2 Tagen, ist die Gelatine längs der Infektionslinie verflüssigt, so dass eine Rinne gebildet wird. Im kondensirten Wasser sammelte sich eine ziemlich grosse Menge des Sedimentes, und zuweilen ist eine dünne Haut auf der Flüssigkeit gebildet. Gelatine wird bereits binnen 2 Wochen ganz verflüssigt.

**Gelatinestichkultur.** Nach 2 Tagen ist die Gelatine in Nähnadelpförmig verflüssigt; nach 4 Tagen ist eine trichterförmige Höhlung gebildet und dann sieht man ein Sediment in ziemlich grosser Menge. Auf der verflüssigten Lösung wird fast immer eine dünne Haut gebildet. Nach etwa 3 Wochen wird die ganze Gelatine verflüssigt, und allmählich ziemlich grauschwarz gefärbt.

**Agarplattenkulturen.** Auf Agarplatten erscheinen bereits binnen 24 Stunden (bei Zimmertemperatur im August) kleine Kolonien, die zuerst einen scharfen Umriss haben und rundlich, nass glänzend und schwach grauweiss sind. Nach etwa einer Woche nehmen diese Kolonien eine rötliche Färbung an, die sich allmählich grauschmutzig und schwarz verändert.

Häufig kommen in den Plattenkulturen einige Riesenkolonien vor, die später konzentrische Kreise bilden. Diese Erscheinungen kommen nicht immer vor, wenn z. B. die Temperatur auf etwa 25°C. gehalten wird. Sehr selten werden konzentrische Riesenkolonien gebildet, welche einen gezackten Umriss haben. Die in Agar tiefliegenden Kolonien sind manchmal elliptisch oder eiförmig, sehr dünn und nach allen Seiten sich ausbreitend; sie sind durch ihren hohen Glanz beim auffallenden Lichte ausgezeichnet. Mehrere rhomboidische Krystalle, welche aus Ammoniummagnesiumphosphat bestehen, kommen häufig in den Agarplattenkulturen vor. Die oberflächlichen Kolonien sehen zuerst weiss aus, aber nach ca. 2 Wochen bei einer Temperatur von 32°C. werden sie grau. Der später gebildete Strahlenkranz hat einen gezackten Umriss. Die in der Tiefe liegenden Kolonien sehen beim auffallenden Licht blauweiss aus, und fluoresciren mehr oder weniger. Ihr Durchmesser beträgt meist 1 mm.. Die oberflächlichen Kolonien sind nicht gekörnt, sondern sehr glatt, ferner feucht und hell in ihrem Centrum. Häufig ist eine Haut auf den Riesenkolonien gebildet.

**Agarstrichkulturen.** In Agarstrichkulturen bei Zimmertemperatur im September, beginnt *BAC. NICOTIANAE* schon binnen 24 Stunden auszuwachsen. Längs der Infektionslinie bildet sich eine weissliche Auflagerung von nassem und glänzendem Aussehen. Binnen einer Woche wird diese Auflagerung mehr oder weniger schleimig. Weder seitenständige fingerähnliche Fortsätze, noch blattförmige Auflagerungen werden gebildet.

**Agarstichkultur.** Nach einer Woche (bei Zimmertemperatur im Juli) findet schnelles Wachstum von *BAC. NICOTIANAE* längs der Stichlinie statt, und besonders auf der Oberseite. Im Infektionspunkt ist das Wachstum der Bacillen am üppigsten; alsdann beginnt eine schwarze Färbung im oberen Theil des Nähragars. Die Auflagerung ist sehr dünn, grauschwarz an der Oberfläche.

**Kartoffeln.** Auf gedämpften Kartoffelscheiben wächst *BAC. NICOTIANAE* bei Zimmertemperatur (Juli) sehr schnell längs der Strichlinie und später ist eine grüngelbliche Auflagerung gebildet. Bereits binnen 1–2 Wochen nimmt das Substrat eine mehr oder weniger grauschwarze Farbe an. Der durch die

Bacillen ausgeschiede Farbstoff löst sich im Wasser auf und diffundirt in das Pflanzengewebe. Auf der Oberfläche von Kartoffelschnitten, wächst *BAC. NICOTIANAE* ziemlich gut (bei Temperatur von 25°C.); bereits binnen 1–2 Wochen wird das Pflanzengewebe gänzlich zerstört. Von dem geimpften Theile aus verbreitet sich *BAC. NICOTIANAE* nach den umgebenden Zellen, welche nun ein feuchtes Aussehen erhalten. Alsdann erfolgt Aushöhlung und Schwärzung des Kartoffelgewebes. Diese Schwärzung des Wirtgewebes ist als ein besonderer Charakter von *BAC. NICOTIANAE* aufzufassen; sie wird durch ein ausgeschiedenes oxidirendes Enzym, Tyrosinase, verursacht.

**Gekochte Möhren, Rettig und Bataten.** Auf gekochten Möhrrüben, sehen die Kolonien von *BAC. NICOTIANAE* zuerst gelblich aus. Nach einigen Tagen produciren sie einen unangenehmen Geruch. Auf gekochten Rettigscheiben erzeugte dieser Bacillus einen scharfen Geruch bereits binnen 1 oder 2 Wochen nach der Infection. Dann erfolgt die Zerstörung der Gewebe. Der Bacillus wächst auch ziemlich gut auf gekochten Bataten.

**Milch.** Der Bacillus wächst sehr gut in Milch. Dieselbe wird durch das Bacterienwachsthum erst stark sauer, das dabei ausgeschiedene Koagulum löst sich aber allmählich ab. Schliesslich nimmt die Milch eine chokoladenartige Färbung an und zeigt eine schwach alkalische Reaction.

**Uschinsky'sche Lösung.** In dieser Lösung findet nur ein geringes Wachstum statt.

**Verhalten gegen verschiedene Temperaturen.** Aus den unter verschiedenen Bedingungen mit vielen Kulturmedien ausgeführten Untersuchungen geht hervor, dass die Optimumtemperatur für das Wachstum Bacillus bei ca. 32°C. liegt. Der Bacillus besitzt keine besondere Widerstandfähigkeit gegen höhere Temperatur. Eine 10 Minuten dauernde Erhitzung des Bacillus in Bouillon auf 54°C. tötete denselben mit Sicherheit ab, während bei 53°C. der Erfolg kein regelmässiger war.

**Verhalten gegen Sauerstoff.** In 3 bis 5 % Zucker enthaltenden Agarstichkulturen wächst *BAC. NICOTIANAE* ziemlich gut, sowohl in der Tiefe als auch an Oberfläche. Er ist fakultativer Anaërob. In einer mit Bouillon gefüllten Gährungsrohre gedeiht er sowohl im geschlossenen als

auch im offenen Teil der Röhre. Auch in KITASATO's und GABRIJSCHESKI's Plattenschale mit Wasserstoffatmosphäre wächst er ziemlich gut.

**Verhalten gegen Wasserstoff.** Wenn Bouillon mit dem Bacillus inficirt und in reiner Wasserstoffatmosphäre gehalten wird, so zeigt sich eine Trübung binnen einer Woche und bildet sich allmählich eine Haut, welche beim Schütteln zerfällt und kleine Zoogloeamassen liefert. Zugleich erhebt sich das Sediment und bleibt lange in der Flüssigkeit suspendirt.

Vergleichen wir die Kulturen von BAC. NICOTIANAE und BAC. CAROTIVORUS mit einander, so ergibt sich manche Aehnlichkeit, aber bei dem letzteren treten schleimige Sedimente auf, bei dem ersteren nicht.

**Säure-Produktion.** Der Organismus producirt in zuckerhaltigen Nährböden eine geringe Menge von Säure. In Peptonwasser tritt dagegen eine schwach alkalische Reaktion ein.

**Reduktionsfähigkeit.** Eine mit 1 % iger Methylenblau-Lösung gefärbte Bouillon wird bald reducirt, wobei die ursprüngliche blaue Farbe verschwindet, wenn die Luft abgehalten wird, sonst tritt an der Oberfläche die blaue Farbe stets wieder auf. Kultivirt man BAC. NICOTIANAE in Kaliumnitrat enthaltenden Lösungen, so kann man nach ein bis zwei Tagen die Reduktion zu Nitrit durch die Griess'schen Reaktionen nachweisen (Metaphenyldiamin oder Sulfanilsäure + *o*-Naphthylamin); das durch Reduktion producirt Nitrit ist besonders bei der letzteren Reaktion leicht erkennbar wegen der intensiv rothen Färbung.

**Indolreaktion.** In jüngeren Kulturen von BAC. NICOTIANAE in einer Lösung von Pepton oder in Bouillon, konnte ich eine schwache Indolreaktion erkennen. Bereits binnen 10 Tagen nach der Infektion von 5 % iger Peptonlösung wurde sie schwarz, so dass die Indolreaktion unmöglich wurde.

**Produktion von Schwefelwasserstoff.** Ich liess einen mit verdünnter Bleiacetatlösung benetzten Filtrierpapierstreifen in den Reagensgläsern hängen, in welchen die Bacillen kultivirt wurden. Binnen einigen Wochen begann das Papier sich zu schwärzen, was die Produktion von Schwefelwasserstoff beweist.

**Verhalten im Erdboden.** Um zu beobachten, wie tief in dem inficirten Erdboden der Welkbacillus wachsen oder wenigstens lebend bleiben kann,



untersuchte ich den Erdboden aus verschiedenen Tiefen im Tabaksfelde bei Nishigahara. Vor allem stellte ich Plattenkulturen von der Erd her; unter den vielen nach einigen Tagen sichtbaren Kolonien waren auch die des Welkbacillus aufzufinden.

Tiefe des Erdbodens.	Beobachtung in der Petrischale.				
3,5 Dm.	Kolonien von BAC. NICOTIANAE sichtbar.				
3,0 „	„	„	„	„	„
2,5 „	„	„	„	„	„
2,0 „	„	„	„	„	„
1,5 „	„	„	„	„	„
1,0 „	„	„	„	„	„
5 Cm.	„	„	„	„	„
Oberfläche des Feldes.	„	„	„	„	„

**Farbstoffbildung.** Der Welkbacillus bildet einen schwarzen Farbstoff, welcher sowohl auf der Wirtspflanze als auch auf den Kulturmedien zuerst als grauweisse dann braune Färbung auftritt. Die Produktion des Farbstoffes hängt von vielen Bedingungen ab, besonders von der Temperatur. Auf Agar, Bouillon, Kartoffel, Gelatine und Milch, wird dieser Farbstoff bei bestimmten Temperaturen nach einigen Tagen gebildet; im August bei etwa 30°C Lufttemperatur erfolgt die Produktion des Farbstoffes sehr schnell. Etwa ein oder zwei Wochen nach der Impfung auf Agar, verändert sich die ursprüngliche grauweisse Farbe der Kolonien zu einer rötlichen, welche sich aber rasch zu einer schwarzen umwandelt. Auf Kartoffeln nimmt die Kolonie des Bacillus zuerst eine grauweisse Färbung an, die sich alsdann in eine schmutzig gelblichgrüne und schliesslich in einer graue oder schwarze verändert. Bouillon und Milch werden gänzlich geschwärzt bei höheren Temperaturen (ca. 35°), wobei oft ein schwarzer Ring an den Glaswänden an der Oberfläche der Flüssigkeit gebildet wird. Der von den Bacillen gebildete Farbstoff ist leicht löslich in Wasser (aus Agarstrich), sehr wenig in Alkohol und Glycerin, nicht in Benzin, Aether und Chloroform. Diese Farbstoffbildung ist keinesweges so beschränkt wie bei dem von Erwin F. Smith beschriebenen BAC SOLANACEARUM, bei welchem die Farbstoffbil-

dung nur in den Alkalien und Glucose enthaltenden Nährflüssigkeiten stattfindet. Unser Bacillus bildet seine braunschwarze Farbe nicht nur in Glucoseagar oder in alkalisch gemachtem Agar, sondern auch in fast allen anderen Nährsubstraten bei 30–40°C.

Ich habe mehrmals Reinigungsversuche des Farbstoffes unternommen nach den Methoden, welche Brieger bei der Untersuchung von *BAC. CYANOGENES* benutzte, doch hatte ich keinen befriedigenden Erfolg.

**Enzymbildung.** Der Welkbacillus scheidet Invertin aus; ich konnte feststellen, dass das Filtrat der Bouillonkultur durch das Chamberland'sche Filter schon nach einen Tag Saccharose invertirt. Auch eine sehr geringe Menge von Diastase scheint er auszusecheiden.

Es scheint mir, dass der Bacillus Cytase ausscheidet; zuerst beobachtete ich bei einem Fragment eines sterilisirten Tabaksstengels, das mit *BAC. NICOTIANAE* geimpft war, mit Hilfe der Tropfenkultur, dass nach 3–4 Tagen die Mittellamellen etwas gequollen waren. Eine Solche Erscheinungen hat Potter auch bei seiner Untersuchung über den Rübenfäulnisbacillus, *PSEUDOMONAS DESTRUCTANS* beobachtet. Der Welkbacillus greift die Zellwände des Tabaks in rechtwinkliger Richtung an, was bei der Tropfenkultur leicht zu beobachten ist. Wenn durch das Chamberland'sche Filter filtrirte Bouillonkultur auf die Oberfläche des Tabaksblattes geimpft wird, macht sich nach zwei oder drei Wochen eine gelblichschwarze Veränderung desselben bemerkbar (August). Diese Tatsache deutet ebenfalls an, dass Cytase durch *BAC. NICOTIANAE* ausgescheiden wird.

Während meiner vorliegenden Untersuchungen beobachtete ich die sehr interessante Tatsache, dass der Bacillus ein oxidirendes Enzym und zwar Tyrosinase ausscheiden kann. Wenn man Paraphenylendendiamin und  $\beta$ -Naphthol (Spitzer's Reaktion) zu einer frischen Agarstrich-oder Bouillonkultur des Bacillus hinzufügt, so entwickelt sich eine schwach rote Färbung, die bald nachher schwarz wird. Wenn man eine 1–5 % ige Tyrosinlösung zu einer Bacillenkultur gibt, so nimmt sie rascher eine rotschwarze Farbe an, als ohne jenen Zusatz. Diese Reaktionen zeigen, dass der Welkbacillus Tyrosinase ausscheidet.

Wenn man einer etwa einen Monat alten Gelatinekultur einige Tropfen

Chlorwassers hinzufügt (nach Neumeisters's Tryptophan Reaktion), verändert sich die Farbe der Lösung zu einer roten; ebenso liefert Brom mit jener Cultur eine violette Färbung. Dies ist characteristisch für die Trypsinverdauung.

### Einfluss der Ernährung auf das Wachstum Gewisser Bakterien.

Vergleichende Versuche mit *B. NICOTIANAE* und anderen Bakterien, um den Einfluss der Ernährung auf ihr Wachstum sowie den von Magnesiumverbindungen auf ihr Farbstoffbildungsvermögen zu beobachten, ergaben die aus der folgenden Tabelle ersichtlichen Resultate:—

		Stickstoffquelle.	Kohlenstoffquelle.	Reakt.
	1).	Pepton 1 %	+     o	Alk.
	2).	„ „	+ Dextrose 1 %	Alk.
	3).	Asparagin 1 %	+     o	Alk.
	4).	„ „	+     o	Sauer.
	5).	„ „ 2 %	+ Dextrose 1 %	Alk.
	6).	„ „ 1 %	+ „ „	Sauer.
Minerallösung. + (	7).	Ammontartarat 1 %	+     o	Alk.
$\text{KH}_2\text{PO}_4$ 1 %	8).	„ „	+ Glycerin 1 %	Alk.
$\text{Mg SO}_4$ 3 %	9).	Kaliumnitrat 1 %	+ Dextrose 1 %	Alk.
$\text{NaCl}$ 0,5 %	10).	„ „	+ Glycerin 1 %	Alk.
	11).	Chlorammon 1 %	+ „ „	Sauer.
	12).	„ „	+ Dextrose 1 %	Sauer.
	13).	Bouillon.		

		<i>B. Nicotianae.</i>	<i>B. solanacearum.</i>	<i>B. lactis niger.</i>	<i>B. Cyanogenes.</i>	<i>B. Pyocyaneus.</i>
1.)	Norm. Entw.	Schw. Entw.	Schw. Entw.	Schw. Entw.	Schw. Entw.	Schw. Entw.
2.)	Stk. Entw.	Norm. Entw.	Norm. Entw.; getrübt.	Keine Entw.	Keine Entw.	Norm. Entw.
3.)	S. Schw. Entw.	Norm. Entw.; Hautbildg.	Schw. Entw.	Schw. Entw.; dünne Hautbildg.	Schw. Entw.; Keine Entw.	Schw. Entw.; grün.
4.)	„ „ „	Keine Entw.	Keine Entw.	Keine Entw.	Keine Entw.	Norm. Entw.; Nicht grün.
5.)	Norm. Entw.; Hautbildg.	Stk. Entw.	Keine Entw.; Weisse dicke Hautbildg.	Norm. Entw.	Norm. Entw.	Stk. Entw.; gelbgrün Fluoresc.
6.)	Keine Entw.	Keine Entw.	Keine Entw.	Keine Entw.	Keine Entw.	Schw. Entw.
7.)	„ „	„ „	„ „	„ „	„ „	Keine Entw.
8.)	„ „	„ „	Schw. Entw.	S. Schw. Entw.	S. Schw. Entw.	Schw. Entw.; grün.
9.)	„ „	Schw. Entw.	Keine Entw.	Schw. Entw.	Schw. Entw.	Stk. Entw.; grün.
10.)	„ „	Norm. Entw.; getrübt.	S. Schw. Entw.	S. Schw. Entw.	S. Schw. Entw.	Norm. Entw.; grün.
11.)	„ „	Keine Entw.	Keine Entw.	Keine Entw.	Keine Entw.	Norm. Entw.
12.)	„ „	Schw. Entw.	Schw. Entw.	Schw. Entw.	„ „	Schw. Entw.; blau.
13.)	Stk. Entw.; Hautbildg.	S. Stk. Entw.	Norm. Entw.; Hautbildg.	Stk. Entw.	Stk. Entw.	Stk. Entw.

Wie diese Tabelle zeigt, wächst *B. NICOTIANAE* üppig, sowohl in der Pepton+Dextrose, als in Asparagin+Dextrose Lösung; für *B. pyocyaneus* scheint jedoch die letztere viel geeignet zu sein als die erstere. Während Asparagin für das Wachstum von *B. Solanacearum* sehr günstig ist, ist es nicht der Fall bei *B. Nicotianae*. Kaliumnitrat-, Chlorammonium-, oder Ammontartrat-lösung (mit Dextrose oder Glycerin) ist für das Wachstum von *B. Nicotianae* nicht geeignet, für *B. pyocyaneus* besser, besonders die erstere ist sowohl für das Wachstum als auch die Farbstoffbildung des Bacillus günstig.

Wiederholte Versuche zeigen, dass die Farbstoffbildung durch *B. NICOTIANAE* von Magnesiumsalzen unabhängig ist.

### Unterschied zwischen *Bac. Nicotianae* und anderen Bacillen.

Es wurden zunächst Kulturen von folgenden Bakterien hergestellt:—

- |                                  |                                   |
|----------------------------------|-----------------------------------|
| 1). <i>Bacillus carotovorus.</i> | 2). <i>B. Cubonianus.</i>         |
| 3). <i>B. vitivorus.</i>         | 4). <i>B. omnivorus.</i>          |
| 5). <i>B. atrosepticus.</i>      | 6). <i>B. Baccarinii.</i>         |
| 7). <i>B. cyanogenes.</i>        | 8). <i>B. mesentericus niger.</i> |
| 9). <i>B. lactis niger.</i>      | 10). <i>B. solanacearum.</i>      |

Die Bacillen Nr. 7-10 bilden einen grauen oder schwarzen Farbstoff, die von Nr. 1-6 aber nicht. Nur die von Nr. 1-6 und auch Nr. 10 sind phytopathogen. In Folgendem sind die Unterschiede von den farbstoffliefernden Bacillen Nr. 7-10 hervorgehoben.

*B. cyanogenes.* Auf alkalisch reagirendem Nähragar bildet der Bacillus einen braunschwarzen Farbstoff, aber einen blauen in einem saurem Nährsubstrat (besonders in Milch); verflüssigt nicht Gelatine; die Stäbchen sind grösser und länger als die des *B. NICOTIANAE*.

*B. lactis niger.* Auf Agar bildet dieser Bacillus einen schmutzig-grauen Farbstoff; die Stäbchen sind grösser als die von *B. NICOTIANAE*. *B. lactis niger* bildet oft fadenförmige Zoogloea und ferner sehr leicht elliptische Sporen, welche denen von *B. subtilis* mehr ähneln als denen von *B. Nicotianae*.

*B. mesentericus niger.* Bildet sehr leicht grosse Sporen in verschiedenen Nährsubstraten; auf Agar oder Kartoffeln bildet er eine faltige Haut, wie der Kartoffelbacillus, was aber *B. Nicotianae* nicht tut.

*B. solanacearum*. Verflüssigt Gelatine weit langsamer, als *B. Nicotianae*. Die ausführlichen vergleichenden Versuche sind wie folgt:—

## BACILLUS NICOTIANAE.

- 1). In Gelatinestrichkultur wächst der Bacillus ziemlich schnell, zuerst weiss, allmählich schwarz.
- 2). Verflüssigt Gelatine ziemlich schnell, binnen etwa 2 Wochen bildet er Häutchen auf der Oberfläche des Gelatinestriches.
- 3). Bildet etwas Gas in Glycoseagar oder Glycosebouillon, und producirt schwach ranzigen Geruch, ferner eine geringe Menge Säure.
- 4). Milch wird anfangs koagulirt aber das Koagulum allmählich gelöst und peptonisirt.
- 5). Auf Kartoffeln bildet der Bacillus einen gelblichgrünen Farbstoff, der allmählich graubraun, zuletzt schwarz wird. Auf Agar werden runde schmutzig weisse Kolonien gebildet, die allmählich braunschwarz werden.
- 7). Wächst am besten bei einer Temperatur von 32°C. Thermaltodpunkt ca. 55°.
- 8). Fakultativ anaerobisch.
- 9). In Peptonbouillon oder Mohrrüben producirt der Bacillus einen unangenehmen Geruch.
- 10). Mit Methyleneblau gefärbte Milch wird leicht reducirt. Durch Griess'sches Reagens kann man die Reduktion von Nitrat zu Nitrit nachweisen.
- 11). Weist eine schwache Indolreaktion auf bei den Kulturen in Peptonlösung.
- 12). Bildet eine Oberhaut auf Bouillon binnen 3-4 Tagen.
- 13). Gram'sche Färbung positiv.
- 14). Sporen und Kapseln vorhanden.
- 15). Parasitisch für *Nicotiana tabacum* und *Capsicum*, nicht aber für Eierpflanze und Tomate.

## BACILLUS SOLANACEARUM.

- 1). Auf Gelatinestrichkultur wächst der Bacillus sehr langsam, längs den Strichlinien. Die Färbung ähnelt mehr oder weniger der von *B. Nicotianae*.
- 2). Verflüssigt Gelatine sehr schwach binnen 5 oder 6 Wochen.
- 3). Bildet auf Kartoffeln oder in glycosehaltiger Nährlösung kein Gas, auch keine Säuren auf Kartoffeln oder in Peptonwasser oder Bouillon, zu welchem Traubenzucker hinzugefügt ist. Neutrale oder schwach sauer reagirende Nährlösung wird rasch alkalisch.
- 4). Milch wird weder peptonisirt noch koagulirt.
- 5). Bildet einen braunen Farbstoff in Nähragar oder in Peptonwasser, welches Traubenzucker enthält. Auf Kartoffel bildet der Bacillus zuerst einen gelblichweissen Farbstoff, welcher dann braun, zuletzt rauchschwarz wird.
- 7). Wächst üppig bei 37°C. Thermaltodpunkt ca. 52°C.
- 8). Streng aerobisch.
- 9). Kein merklicher Geruch in den verschiedenen Kulturmedien.
- 10). Es sind keine Reduktionsvorgänge wahrnehmbar.
- 11). Keine Indolreaktion.
- 12). In Bouillon oder Peptonlösung, bildet binnen 1-2 Wochen.
- 13). Gram'sche Färbung negativ.
- 14). Weder Sporen noch Kapseln.
- 15). Parasitisch für Eierpflanze und Tomate, nicht aber für *Nicotiana* und *Capsicum*.

### Diagnose des *Bac. Nicotianae* und Schlussbemerkungen.

B. NICOTIANAE gehört zu den kleinen Bakterien mit runden Enden; die Stäbchen sind 1,0—1,2  $\mu$  lang und 0,5—0,7  $\mu$  dick. Er bleibt oft isolirt, zuweilen zu 2—4 verbunden. Bewegung durch mehrere peritriche Geisseln. Wächst üppig auf gewöhnlichen Nährsubstraten und verflüssigt Gelatine. Auf Kartoffeln bildet der Bacillus anfangs eine gelblichgrüne Auflagerung, welche nach einer Woche grauschwarz wird. Fakultativ anaërob. Liefert nur schwache Gasentwicklung. Reducirt leicht Lakmusmilch und Methylblau, ferner Nitrat zu Nitrit. Koagulirt Milch, das Koagulum wird dann allmählich gelöst und peptonisirt.

Optimumtemperatur für das Wachstum 32°C.; Maximumtemperatur 55°C.

Auf vielen Nährsubstraten producirt der Bacillus einen schwarzen oder grauschwarzen Farbstoff. Trypsin und Tyrosinase werden sicher ausgeschieden.

Der Bacillus ist in welkkranken Tabakspflanzen in verschiedenen Gegenden in Japan vorhanden und ist die Ursache der sogenannten Welkkrankheit. Der Bacillus greift verschiedene Varietäten von Tabakspflanzen an, nicht aber *Nicotiana rustica*; auch einige Varietäten von *Nicotiana tabacum* (Ōhasama, Taketadate, Mitsuke, Kentucky white, Green river prior) werden nicht leicht angegriffen. Impfversuche auf *Physalis minimum*, *Capsicum longum*, *Amarantus gangeticus* und *Polygonum tinctorium* fielen positiv, aber bei *Solanum melongena*, *Lycopersicum esculenta*, und *Physalis Alkekengi* negativ aus.

Die Frühpflanzung ist ein Schutzmittel gegen die Tabakwelkkrankheit.

Die Austrocknung des inficirten Tabaksfeldes bei höheren Sommertemperaturen ist für den Zweck der Vernichtung des Welkbacillus sehr wichtig. Auch das Brennen des inficirten Erdbodens wirkt ohne Zweifel günstig, wenn es auch schwer auszuführen ist.  $CS_2$  und Aetzkalk sind für die Vernichtung des Bacillus mehr oder weniger brauchbar. Für die Tabaksbauer ist die Klärung der inficirten Tabaksfelder z. B. Verbrennung der erkrankten

Pflanzen zu empfehlen. Stickstoffreiche Düngung disponiert die Pflanzen zur Welkkrankheit, aber Kalidüngung nicht.

Es mag noch die Frage aufgeworfen werden, ob denn die durch die Welkkrankheit zu Grunde gegangenen Pflanzen gar keine Verwertung mehr finden könnten? Darauf sei erwidert, dass die Blätter nach einem raschen "Flue-curing" wohl als geringere Qualitäten von Pfeifentabak noch verwertet werden könnten. Ferner kann ein Extrakt daraus hergestellt werden; Tabaksextrakt hat als insektentötendes Mittel bekanntlich einen bedeutenden Wert.

Zum Schluss spreche ich Herrn Direktor, Professor Y. Kozai, für gütige Unterstützung bei dieser Arbeit meinen besten Dank aus.

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## TAFELERKLAERUNG.

### TAFEL IV.

- Fig. 1. Erkrankte Tabakspflanzen im Tabaksversuchsfeld bei Ōta (1904 phot. von Herrn Dr. G. Daikuharā).
- Fig. 2. a) Kranke Tabakswurzel. (1903 phot.)
- Fig. 2. b) Gesunde Tabakswurzel.

### TAFEL V.

- Fig. 3. Kranke Tabakspflanze mit welken Blättern und schwarzem Stengel. (ca. 1/2 verkürzt.)
- Fig. 4. Längsschnitt des Stengels einer welken Tabakspflanze. (nat. Grösse.)
- Fig. 5. Querschnitt „ „ „ „ „

### TAFEL VI.

- Fig. 6. Querschnitt von einer erkrankten Tabakspflanze. (ca. 115 mal vergr.)
- a) Wenig erkrankte-, b) starke erkrankte, contrahierte Gewebe.
- Fig. 7. Querschnitt durch den erkrankten Tabaksstengel (ca. 140 mal.)
- Fig. 8. a) Mit *B. Nicotianae* bespritzte Blätter (2 Wochen nach Spritzung). (S. Nagai del.)
- b) Querschnitt eines erkrankten Tabaksblattes, besonders die Spiral- und Tüpfelgefässe des Blattnerve sind erfüllt mit dem Bacillus.
- Fig. 9. Erkrankte Tabaksgewebe, Zellkern löst sich allmählich.

### TAFEL VII.

- Fig. 10. Gelatinestrichkultur des *B. Nicotianae* (eine Woche nach Inficirung).
- Fig. 11. Gelatinestichkultur des Bacillus.
- Fig. 12. Agarplattenkultur von *B. Nicotianae*; Kolonien 8 Tage alt, weisslich.

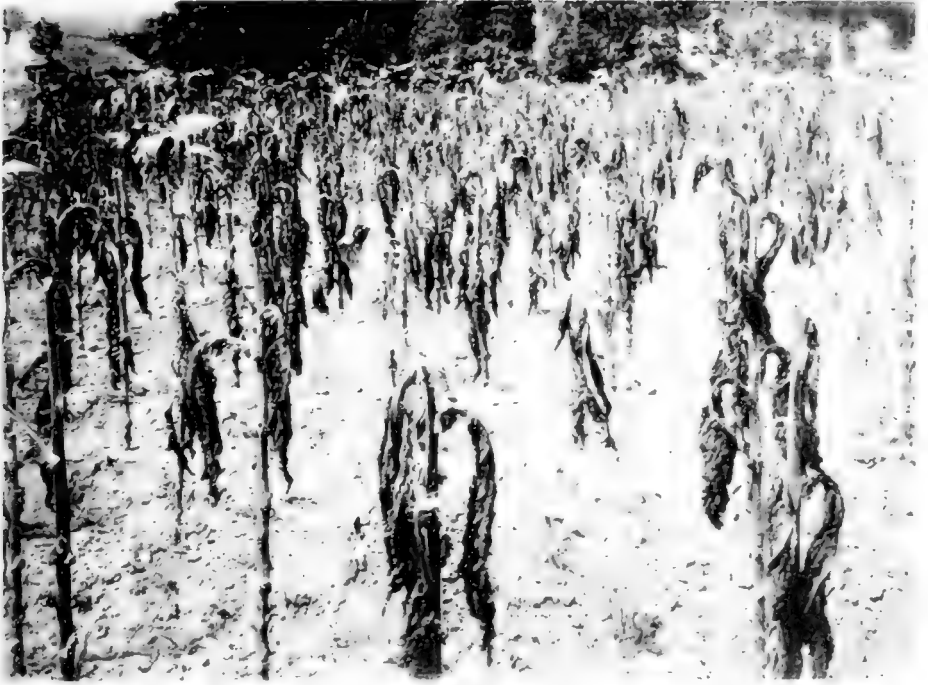


- Fig. 13. Agarplattenkultur von *B. Nicotianae*; a) weisse Kolonien, b) konzentrische, 2 Wochen alte, schwarze Kolonien.

## TAFEL VIII.

- Fig. 14. Agarstrichkultur; Auflagerung schneeweiss.  
Fig. 15. Agarstrichkultur mit schwarz gefärbter Auflagerung. (2 Wochen alt).  
Fig. 16. Agarstichkultur.  
Fig. 17. Kartoffelscheiben-Kultur, schwarze Auflagerung (2 Wochen alt).  
Fig. 18. Bouillonkultur (eine Woche alt).  
Fig. 19. Milchkultur (nach 2 Wochen).  
Fig. 20. Mikrophotographie von *B. Nicotianae* (ca. 1000 mal verg.) (Phot. von Herrn S. Nagai).  
Fig. 21. *B. Nicotianae* (ca. 1200 mal verg.).
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1

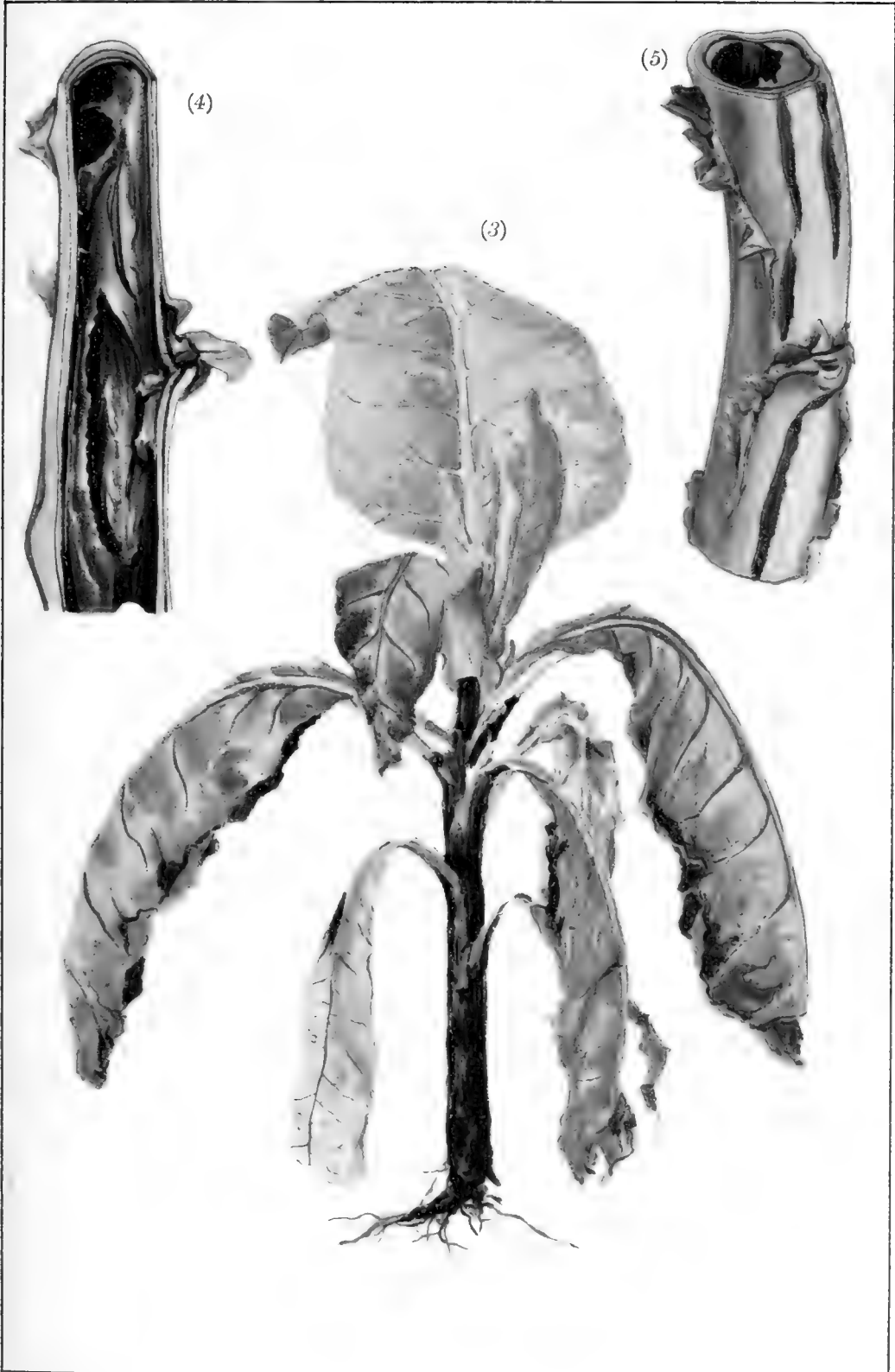


(a.)

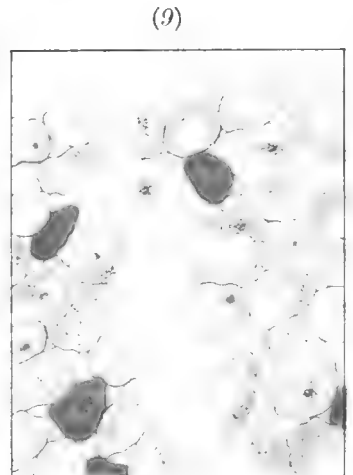
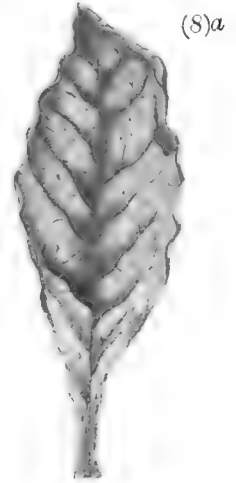
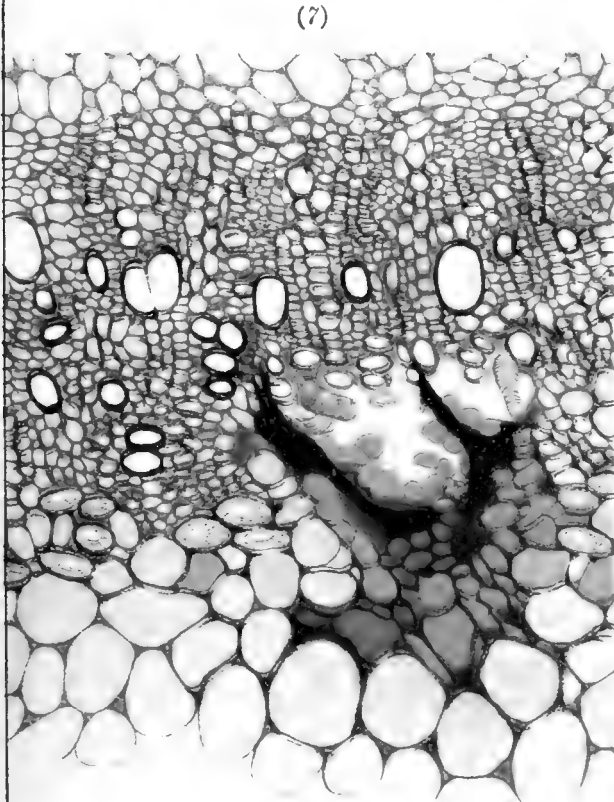
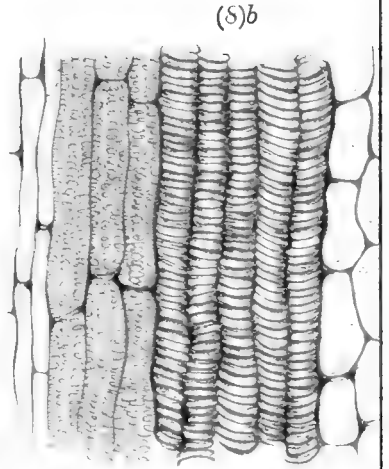
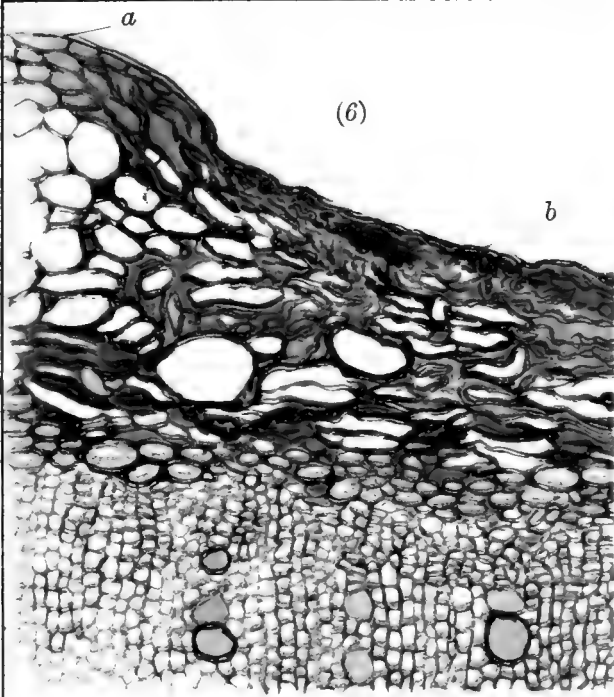
(b.)

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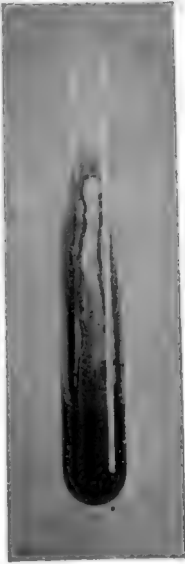




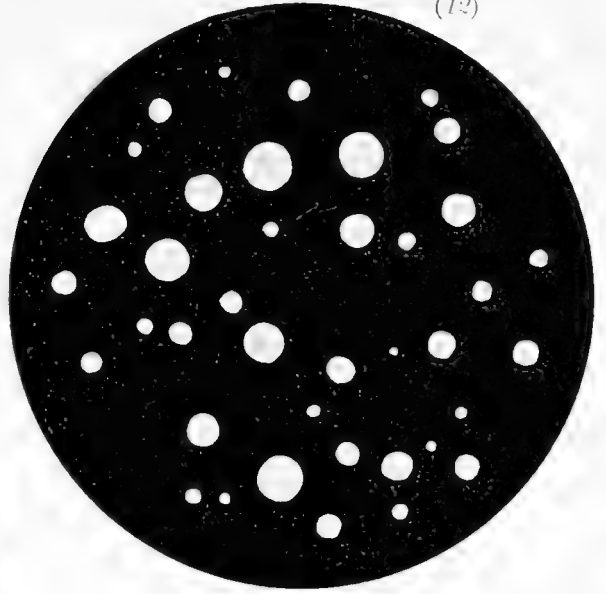




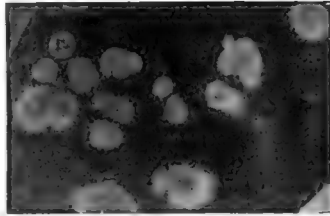
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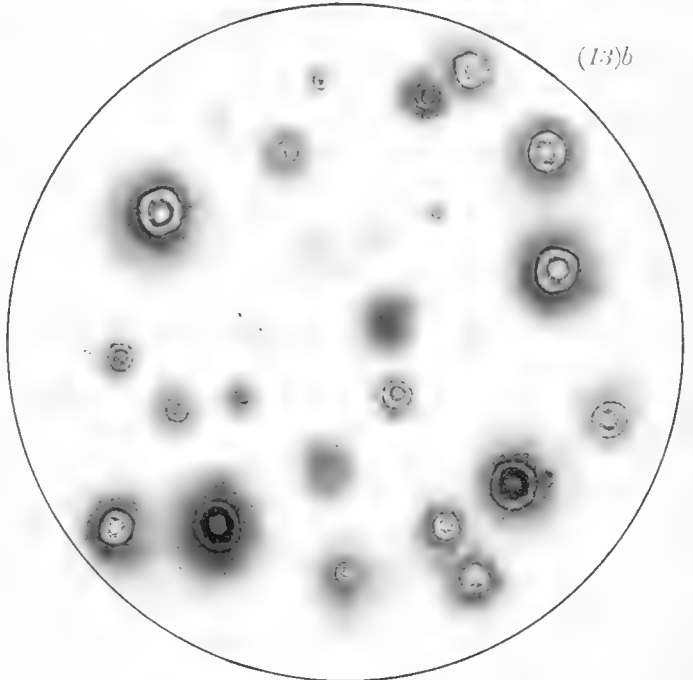
(12)



(13)*a*



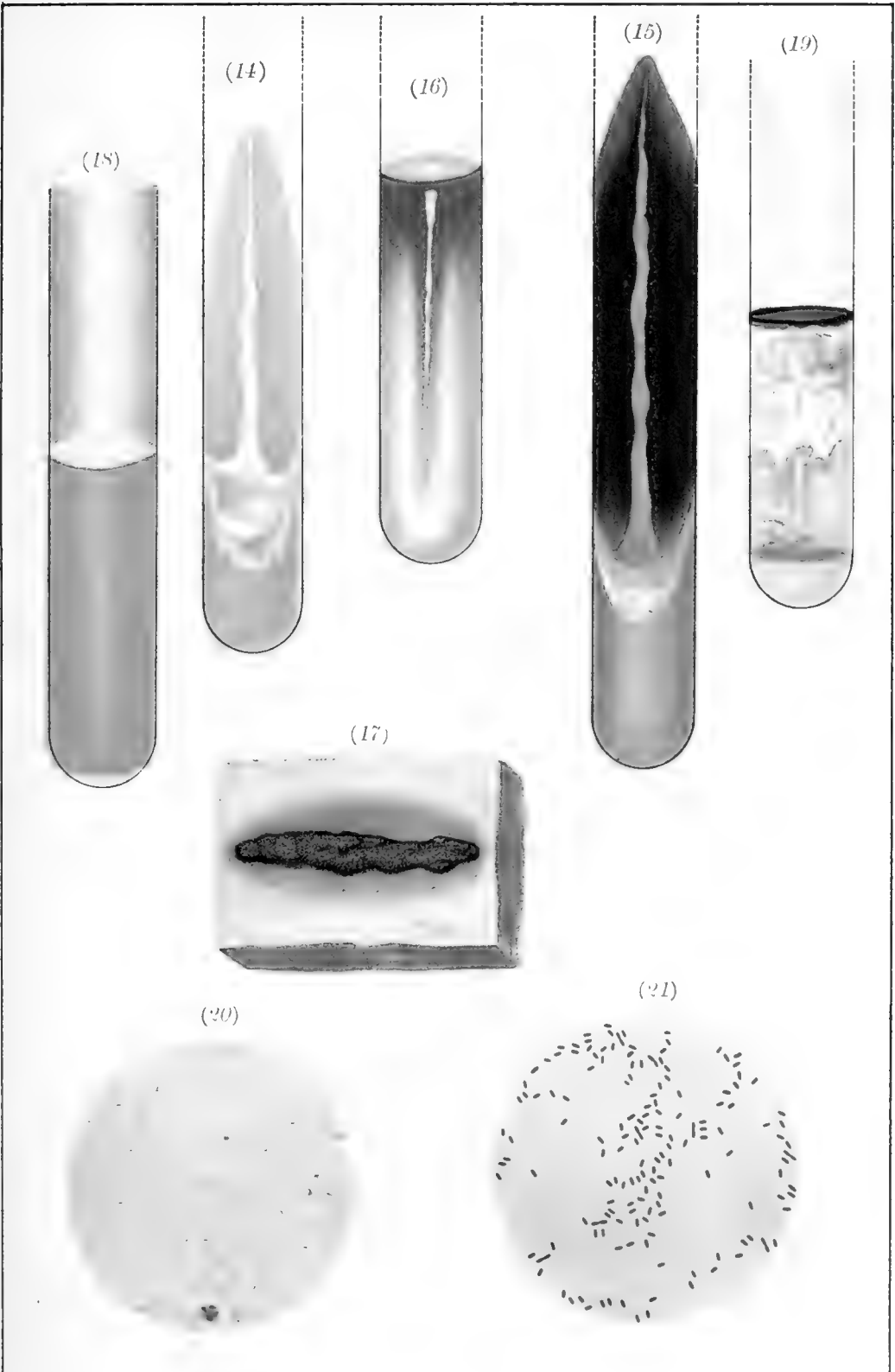
(13)*b*



(11)









# Ein neuer Nährboden für Bakterienkulturen.

VON

Y. Uyeda.

Eine wertvolle Substanz behufs Diagnose und Charakterisierung von Bakterien ist das Mannan. Dieses Kohlenhydrat ist in den meisten Pflanzen nur in geringer Menge, in einigen pflanzlichen Objekten aber in sehr bedeutenden Mengen enthalten, und zwar kommt es in mehreren Modifikationen vor, in Analogie mit den verschiedenen Dextrinen. Eine Mannan-Modifikation, (A), bildet eine specielle Art Pflanzenschleim, z. B. in den Salepwurzel und in der Hefe; eine zweite Modifikation, (B), bildet beim Kochen eine Gallerte, einem kompakten Stärkekleister ähnlich, besonders ist hier das Mannan der Wurzel der Konyaku-Pflanze<sup>1)</sup> *Conophallus Konjak* (*Amorphophallus Rivieri* oder *Hydrosme Rivieri*) zu erwähnen; eine dritte Modifikation, (C), bildet die steinharte Masse der Steinnus, welche weit schwieriger zu hydrolysieren ist, als die ersteren beiden Modifikationen.

Zu meinen Untersuchungen diente das Mannan (B) oder Konyaku-Mannan, welches meist in Form der in Japan käuflichen Gallerttafeln verwendet wurde, um verschiedene Bakterien-Auflagerungen, sowie deren Form und Farbe und Fähigkeit, die Gallerte zu verflüssigen, zu beobachten.<sup>2)</sup> Diese Verflüssigung, welche wie ich beobachtete durch verschiedene Bakterienarten herbeigeführt wird, die demnach ein specielles Enzym, Mannase, enthalten, liess sich meist schon bei Zimmertemperatur beobachten,

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1) Diese Wurzel kommt im gepulverten Zustand im Handel in Japan vor und bildet nach dem Kochen mit Kalkwasser (wobei eine kratzend schmeckende Substanz zerstört wird) einen Nahrungsartikel, der in Form steifer Gallerttafeln verkauft wird.

2) Die gewöhnliche Diastase scheint nicht auf Mannan zu wirken. Da nun das Konyaku-Mannan im menschlichen Darms in Japan verdaut wird, wird wohl Mannase auch zu den Darmenzymen gehören. Kürzlich haben allerdings *C.L. und Mme. Gatin* beobachtet, dass der Pankreassaft verschiedener Tiere das Mannan der Salepwurzel nicht zu hydrolysieren vermag. (*Botan. Centrbl.* 1905, Sept.)

während für das verwandte Galaktan, den wesentlichen Bestandteil des Agar-Agar, ein entsprechendes Enzym—die Galaktase—in den Bakterien gar nie vorzukommen scheint.<sup>1)</sup> Ich habe jedoch auch das Konyaku-Mannan in der gleichen Weise wie es bei Agar oder Gelatine üblich ist, zu Stickskulturen verwendet. Zu diesem Zweck wurde ein Teil Wurzel-Pulver mit 25 Teilen Wasser eine Stunde im kochenden Wasserbade behandelt, dann weiter sterilisiert, wie üblich. Die käuflichen Konyaku-Tafeln aber wurden, sterilisiert, ganz wie Kartoffelschnitte zu den Versuchen verwendet.

### STRICKKULTUREN AUF KÄUFLICHEN KONYAKUTAFELN.

Folgende Versuche mit 132 Arten beziehen sich auf deren Entwicklung auf Konyakutafeln bei 16° sowie bei 30°C.

#### TAFEL I.

##### (A) Mannan verflüssigende Bakterien.

##### (a) Auf Agar chromogene Arten.

Art der Bakterien.	Charakter und Farbe der Auflagerung.	Zeit der Verflüssigung des Mannans.	Vergl. mit Agar
<i>Bac. mesentericus niger.</i>	Gute Entwicklung bei 16°: bräunlich weiss, feuchtglänzend.	Allmählich mit Bildung eines Canals.	
<i>Bac. fluorescens liqifaciens.</i>	Ziemlich gute Entwicklung bei 16°, grünlich feuchtglänzend.	Allmählich unter Bildung von Schleim.	
Konyaku Bacillus <sup>2)</sup>	Schnelles Wachstum bei 16° mit Bildung eines dunkeln Farbstoffs.	Rasche Verflüssigung und Canalbildung.	Auflagerung farblos.

1) Nur ein von *Grise* beobachtetes Mikrob aus dem Meere, *Bac. gelaticus*, besitzt die Fähigkeit, Galaktan zu verflüssigen, was biologisch interessant ist, da gerade auch die marinen Algen reich an Galaktan sind. Unter den höheren Pilzen enthält nach *Grise* *Ustilago Maydis* ein Galaktan verdauendes Enzym, da Tragant (nicht aber Mannan des Datelendosperms) gelöst wird. (Botan. Centrbl. 1902, Bd. 31).

2) Verursacht eine Blattkrankheit der Konyakupflanze.

## (b) Auf Agar farblose Arten.

Astasia astero- sporus.	Nach einer Woche, schmutzigweiss, feuchtglänzend.	Rasche Verflüssigung; der innere Teil der Auflagerung sinkt ein.
Bac. erythrosporus.	Ziemlich gute Entwicklung, weiss.	Sehr langsame Verflüssigung.
Bac. leptosporus.	Rasche Entwicklung, schmutzigweiss.	Binnen einer Woche.
Bac. mesentericus vulgatus.1)	Grauweisser, runzeliger Belag. Allmählich etwas schleimig werdend.	Allmählich: Auflagerung einsinkend.
Säurefester Bac. a. Butter Rabinow.	Schmutzigweiss; feuchtglänzende, hohe Auflagerung.	Allmählich
Bakterium turgescens.	Ziemlich schnelles Wachstum; schmutzigweiss, rasch sich ausbreitend.	Ziemlich schnell.
Planosarcina ureae.	Langsames Wachstum; weiss.	Allmählich.

TABELLE II.

## (B) Mannan nicht verflüssigende Bakterien.

## (a) Auf Agar chromogene Arten.

Art der Bakterien.	Charakter und Farbe der Auflagerung.	Vergl. mit Agar.
Bac. amylobacter.	Schnelles Wachstum bei 30°: die ganze Tafel wird bald rot.	
Bac. capsulatus roseus.	Ziemlich gute Entwicklung; weiss.	Rosafarbe.
Bac. ferruginosus.	Grünlich, dünn, rasch sich ausbreitend.	
Bac. fuchsianus.	Metallisch glänzend, rotviolett in Scheiben sich ausbreitend, höher in der Mitte.	

1) Vergl. Bul. College Agr. Tokio. Vol. 5, No. 2, p. 260.

<i>Bac. havaniensis.</i>	Ziemlich gute Entwicklung; gelblich.	Rot.
<i>Bac. lactis niger.</i>	Bräunlich, feuchtglänzend.	
<i>Bac. nicotianae.</i>	Weiss, später schwach bräunlich.	Schwarz.
<i>Bac. mycoides roseus.</i>	Schnelles Wachstum bei 16°; schwach rötlich, etwas faltig.	Dunkelrot.
<i>Bac. prodigiosus.</i>	Ziemlich gute Entwicklung; anfangs hellblutrot später dunkelrot.	
<i>Bac. pyocyaneus</i> Gessard.	Ziemlich schnelles Wachstum; grünlich-weiss.	
<i>Bac. pyocyaneus</i> Ernst.	Verbreitet sich schnell über die ganze Oberfläche; bald grauweiss werdend.	Schwach grünlich.
<i>Bac. ruber balticus.</i>	Ziemlich gute Entwicklung; rötlich.	
<i>Bac. ruber plymouthensis.</i>	Sehr dünn, rosafarbig, feuchtglänzend.	
<i>Bac. viridans.</i>	Schnelles Wachstum bei 16°; verbreitet sich binnen 3 Tagen über die ganze Oberfläche, allmählich grünlichblau.	
<i>Bakterium aquatile</i> <i>citreum.</i>	Schön grüne hohe Auflagerung mit Canalbildung.	
<i>Micrococcus agilis,</i>	Ziemlich schnelles Wachstum: fast immer farblos.	Dunkelrot.
<i>Microc. pyogenes aureus.</i>	Ziemlich schnelles Wachstum: weiss, feingranuliert.	
<i>Planosarcina agilis.</i>	Langsames Wachstum bei 16°: sehr schwach rosafarbig.	Dunkelrot.
<i>Pseudomonas phaseoli.</i>	Ziemlich schnelles Wachstum bei 30°; gelblichgrün.	
<i>Sarcina striata.</i>	Schön gelblichgrün, feuchtglänzend, hoher in der Mitte.	
<i>Sarcina variabilis.</i>	Ziemlich schnelles Wachstum bei 16°; gelblichgrüne, hohe Auflagerung.	
<i>Sarcina aurantiaca.</i>	Langsames Wachstum bei 16°, schwach-gelblich.	Schön orangegeiß
<i>Sarcina citrina.</i>	Schwach gelblichgrün, feuchtglänzend.	
<i>Sarcina erythromyxa.</i>	Langsames Wachstum bei 16° sowie bei 30°; gelblichbrauner, feingranulirter Belag von trockenem Aussehen.	Karminrot.
<i>Sarcina liquifaciens.</i>	Ziemlich gute Entwicklung; schwach gelblichgrün.	



<i>Sarcina mobilis.</i>	Sehr langsames Wachstum bei 16°; gelblich.	
<i>Spirillum rubrum.</i>	Langsames Wachstum; Weiss.	Rötlich.

## (b) Auf Agar farblose Bakterien.

<i>Bac. alvei.</i>	Ziemlich gute Entwicklung bei 30°; weiss, feuchtglänzend.	Weiss, später braun.
<i>Bac. angulans.</i>	Sehr langsames Wachstum bei 30°; schmutzigweiss.	
<i>Bac. anthracoides.</i>	Ziemlich gute Entwicklung bei 30°; schmutzigweiss.	
<i>Bac. armoraciae.</i>	Gute Entwicklung bei 16°; schmutzigweiss, rasch sich ausbreitend.	
<i>Bac. atrosepticus.</i>	Sehr langsames Wachstum bei 16°; schmutzigweiss.	
<i>Bac. aerogenes.</i>	Langsames Wachstum bei 30°; schmutzigweiss.	
<i>Bac. Baccarinii.</i>	Schnelles Wachstum bei 16°; feuchtglänzend, schmutzigweiss.	
<i>Bac. bombycis.</i>	Ueppige Entwicklung bei 30°; weiss feuchtglänzend, später braun.	Weiss.
<i>Bac. butyricus.</i>	Sehr langsames Wachstum bei 30°; schmutzigweiss.	
<i>Bac. cereus.</i>	Sehr langsames Wachstum bei 16°; gelblichweiss.	
<i>Bac. Cubonianus.</i>	Schwachgelblichgrün, höher in der Mitte.	Weiss.
<i>Bac. denitrificans.</i>	Ziemlich schnelles Wachstum; schmutzigweiss.	
<i>Bac. Ellenbacchii Caron.</i>	Ueppiges Wachstum bei 16°, sich rasch ausbreitend.	
<i>Bac. d. Flacherie d. Nonne.</i>	Ziemlich gute Entwicklung bei 16°; weiss feuchtglänzend, feingranuliert Auflagerung mit Fortsätzen in der Peripherie.	
<i>Bac. fluorescens longus.</i>	Langsames Wachstum bei 30°; schmutzigweiss.	

Bac. fluorescens albus.	Sehr langsames Wachstum bei 30°; farblos feuchtglänzend, feingranuliert.	
Bac. fluorescens mesentericus.	Langsames Wachstum bei 30°; schwach gelblichgrün.	Weiss.
Bac. mycoides.	Schmutzigweiss, feuchtglänzend, feingranuliert.	
Bac. omnivorus.	Schnelles Wachstum bei 16°; weiss.	
Bac. proteus mirabilis.	Langsames Wachstum bei 16°; farblos.	
Bac. proteus vulgaris.	Langsames Wachstum bei 16°; schmutzigweiss, dünner Belag mit unregelmässigem Rand.	
Bac. ruminatus.	Langsames Wachstum bei 30°; schwach schmutzigweiss, feuchtglänzend.	
Bac. simplex.	Sehr langsames Wachstum bei 30°; schmutziggelblichweiss.	
Bac. typhi murium Löffler.	Langsames Wachstum bei 16°; farblos, allmählich schmutzigweiss.	Farblos.
Mereshkowsky's Mäusetyphusbacillus.	Ueppige Entwicklung bei 16°; gelblichweiss; Belag trocken in der Mitte, aber feuchtglänzend an der Peripherie.	Farblos.
Bac. vermiculosus.	Langsames Wachstum bei 30°; feuchtglänzend, gelblichbraun; Auflagerung allmählich einsinkend.	
Bakterium aquatile griseum.	Ueppige Entwicklung bei 30°; schwach blau, etwas klebrig werdend.	
Bakterium centropunctatum.	Farblos, trockene Auflagerung mit strahligem Rand.	
Bakterium filefaciens.	Farbloser, trockener Belag, von pulverigem Aussehen.	
Bakterium filiforme.	Schnelles Wachstum bei 16°; schmutzigweisser, feuchtglänzender Belag, rasch sich ausbreitend.	
Bakt. Hartlebi.	Schwachbräunlich.	
Bakt. nitrovorum.	Trockener, feingranulirter Belag mit regelmässigem Rand. Schmutzig gelblichweiss.	Weiss.
Bakt. vesiculosum.	Schmutzigweiss, feuchtglänzend.	
Cladothrix nivea.	Schmutzigweisser, feuchtglänzender Belag, höher in der Mitte.	

<i>Clostridium gelatinosum.</i>	Schnelles Wachstum bei 30°; schmutzig-gelblichweiss.
<i>Diplococcus concentricus.</i>	Schmutzig gelblichweiss.
<i>Micrococcus cremoides.</i>	Schmutzigweiss.
<i>Microc. ureae.</i>	Gute Entwicklung bei 16°; farblosen feuchtglänzender ziemlich dicker Belag.
Milch <i>Bacillus</i> Möller.	Ueppige Entwicklung bei 30°; schmutzigweisser trockener Belag, später faltig.
<i>Tyrothrix turgidus.</i>	Langsames Wachstum bei 30; schwach gelblichgrün.
<i>Eac. pavoninus.</i>	Ziemlich gutes Wachstum bei 30°; farblos.

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Die auf Konyakutafeln spärlich sich entwickelnden Bakterien sind folgende :

*Bac. aromaticus lactis.*, *Bac. arborescens.*, *Bac. candicans.*, *Bac. cavida.*, *Bac. cyanogenes.*, *Bac. filamentosus.*, *Bac. denitrificans agilis.*, *Bac. Fitzianus.*, *Bac. fusiformis.*, *Bac. levans.*, *Bac. lucifer.*, *Bac. maidis.*, *Bac. ochraceum.*, *Bac. raditicola v. trifolium pratense.*, *Bac. repens.*, *Bac. roseofluorescens.*, *Bac. ruber indicus.*, *Bac. subtilis.*, *Bakterium aquatile odorans.*, *Bakt. agile.*, *Bakt. Fränkeri.*, *Bakterium Monache.*, *Bakterium radiatum.*, *Bakt. Stutzeri.*, *Coccobacterium aquae.*, *Micrococcus cinnabareus.*, *Microc. citreus agilis.*, *Micrococ. sulfureus.*, *Microc. tetragenes.*, *Micrococ. viticulosus.*, *Microc. tetragenes ruber.*, *Mikrospira Metschnikowii.*, *Sarcina equi.*, *Sarcina fusca.*, *Vibrio aquatilis fluorescens  $\alpha$  &  $\beta$ .*, *Bac. typhosus.*, *Cholera Asiaticae.*, *Bac. anthracis.*, *Vibrio denitrificans.*, *Bac. Pasteurianus.*, *Bac. cyanofluorescens.*, *Sarcina ventriculi.*

#### STICHKULTUREN IN KONYAKUGALLERTE.

Für die Stichkulturen wurde eine Konyakugallerte hergestellt aus 1 Teil feinem Pulver von Konyakuwurzel und 25 Teilen Wasser; in vielen Fällen wurden noch bestimmte Nährstoffe zugesetzt. Die geprüften Bakterienarten waren hier folgende :—

## TABELLE III.

## (A) Mannan verflüssigende Bakterien.

Art der Bakterien.	Verhalten zu Kanyakugallerte (im Brutschrank bei 30°C)	
	Mit Bouillon.	Ohne Bouillon.
<i>Bac. fluoresc. liquifaciens.</i>	Gutes Wachstum; ziemlich schnelle Verflüssigung; es bildet sich eine fleischfarbige gallertige Haut, und reichlicher Bodensatz; grünfluoreszierend.	Langsames Wachstum.
<i>Bac. mesentericus niger.</i>	Ziemlich schnelle Verflüssigung; runzlige Haut.	Schnelle Verflüssigung. Schwachgelblich.
<i>Bac. mesentericus vulgatus.</i> <sup>1)</sup>	Gute Entwicklung; schnelle Verflüssigung; es bildet sich eine gallertartige Haut und reichlicher Bodensatz; die Lösung schwach chokoladbraun.	Ueppige Entwicklung.
<i>Astasia asterosporus.</i>	Schmutzigweiss Auflagerung; langs dem Stichcanal entwickeln sich einzelne Gasblasen. Langsame Verflüssigung.	Keine Entwicklung.
<i>Bac. pyocyaneus.</i> Gessard.	Ziemlich schnelle Verflüssigung; es bildet sich grünlichweisse, dünne Haut und reichliches Sediment.	
<i>Bac. viridis.</i>	Schnelles Wachstum; grauweisse feuchtglänzende Auflagerung, welche allmählich einsinkt.	Schnelles Wachstum, aber langsame Verflüssigung; schwach gelblichweiss.
<i>Planosarcina ureae.</i>	Schnelles Wachstum; gelblichweiss, feuchtglänzend; sehr langsame Verflüssigung.	Schlechtes Wachstum.
Konyaku Bacillus.	Ziemlich schnelle Verflüssigung; es bildet sich Haut und Sediment, aber die Lösung bleibt klar.	Rasche Verflüssigung, weiss.

1) Vergl. Bull. Coll. Agr. Tokio Univers. Vol. 5, No. 2, p. 260.

Bac. leptosporus.	Schnelles Wachstum; weiss. Rasche Verflüssigung.	Gute Entwicklung, ziemlichschnelle Verflüssigung, es bildet sich reichlicher Bodensatz und Haut.
Bakterium turgescens.	Schnelles Wachstum; radiäre Auflagerung, dunkelbraun in der Mitte, farblos, feuchtglänzend an der Peripherie.	Gute Entwicklung, ziemlich langsame Verflüssigung, reichlicher Bodensatz.

## (B) Mannan nicht verflüssigende Bakterien.

Bac. alvei.	Ueppige Entwicklung; weiss.	Ziemlich gute Entwicklung; weiss.
Bac. bombycis.	Schnelles Wachstum; weiss.	Ziemlich ueppige Entwicklung; weiss.
Bac. acidilactici.	Schnelles Wachstum; grauweiss, feuchtglänzend.	Sehr langsames Wachstum; weiss.
Bac. coli communis.	Schnelles Wachstum; farblos.	Langsames Wachstum; farblos.
Bac. Cubonianus.	Ueppige Entwicklung; sich über ganze Oberfläche ausbreitend, Haute langs den Glaswänden.	Ueppige Entwicklung; weiss.
Bac. cohörens.	Schnelles Wachstum; runde glänzende Auflagerungen, gelblichgrauweiss in der Mitte, grauweiss, feuchtglänzend an der Peripherie.	
Bac. capsulatus.	Gute Entwicklung; weiss, glänzend später schmutzig gelblichweiss in der Mitte, aber schmutzigweiss, feuchtglänzend an der Peripherie.	Ziemlich gute Entwicklung; schmutzigweiss.
Bac. filamentosus.	Ziemlich gute Entwicklung; runzelige, an den Glaswänden emporsteigende Auflagerungen.	
Bac. d. Flacherie d. Nonne.	Ueppige Entwicklung; weiss.	
Bac. fluorescens mesentericus.	Ziemlich gute Entwicklung; schwach grünliche dicke Auflagerung; breitet sich schnell aus.	
Milch Bacillus Möller.	Langsames Wachstum; weiss.	
Bac. Nicotianae.	Ziemlich gute Entwicklung; schwach blau, glänzend, später bräunlich.	Langsames Wachstum; schwach bräunlich.

<i>Bac. prodigiosus.</i>	Gute Entwicklung; glänzende, dunkel karmesinrote Auflagerung, allmählich einsinkend.	Ziemlich schnelles Wachstum; schwach rosa Farbe.
<i>Bac. repens.</i>	Ueppige Entwicklung; weiss.	Schlechte Entwicklung.
<i>Bac. radicola v. Pisum sativum.</i>	Langsames Wachstum; weiss.	
<i>Bac. typhi mur.</i>	Schnelles Wachstum; weiss, später gelblichweiss, breitet sich schnell aus.	Schlechte Entwicklung.
<i>Bac. vermiculosus.</i>	Schnelles Wachstum; schwach blau, feuchtglänzende Auflagerung, später dunkelbraun in der Mitte.	
Bakterium agile.	Ueppige Entwicklung; farblos.	Schlechte Entwicklung.
Bakterium denitrificans.	Schnelles Wachstum; weiss.	
Bakterium filefaciens.	Schnelles Wachstum; entwickelt Gasblasen im Stichcanal; schwach gelbliche, glänzende Auflagerung, allmählich einsinkend in der Mitte, mit strahligem Rand.	
Bakterium filiforme.	Schnelles Wachstum; entwickelt Gasblasen; weisser trockener Belag, allmählich schmutzigweiss werdend, grauweiss an der Peripherie.	
Bakterium Hartlebi.	Langsames Wachstum weiss	
Bakterium nitrovorum.	Schnelles Wachstum; rosenkranzähnliche Auflagerung dunkelfärbig in der Mitte, aber weiss an der Peripherie.	
Bakterium Stutzeri.	Langsames Wachstum; weiss.	
Bakterium der seifigen Milch.	Gedeiht ueppig auf der Oberfläche sowie im Stichcanal; grauweiss.	
<i>Micrococcus citreus agilis.</i>	Schnelles Wachstum; schwach gelblichgrüner Belag.	
<i>Micrococcus ureae.</i>	Ziemlich gute Entwicklung; weiss, glänzend und gelatinös.	
<i>Planosarcina agilis.</i>	Langsames Wachstum; weiss, später schwach rot.	
<i>Sarcina citrina.</i>	Schnelles Wachstum; Belag mit zackigem Umriss, allmählich einsinkend; dunkelbraun.	
<i>Sarcina erythromyxa.</i>	Langsames Wachstum; feingranulit Belag, gelblichgrün später dunkelnd.	Sehr langsames Wachstum; weiss.
<i>Sarcina meliflava, Sarcina striata.</i>	Langsames Wachstum; gelblichgrün. Ziemlich gute Entwicklung; gelblich.	Langsames Wachstum; gelblich.

# Über die bactericide Wirkung des phenylpropionsauren Natrons.

VON

Y. KOZAI.

Es war seit lange das Bestreben der Aerzte, eine Substanz zu finden, welche mit stark bactericiden Eigenschaften begabt und doch zugleich möglichst unschädlich für tierische Zellen wäre. Wenn wir mehrere Sera und die Pyocyanase ausnehmen, so sind solche Substanzen kaum bekannt. Doch scheint das phenylpropionsaure Natron, wenigstens bis zu einem gewissen Grade, jener Anforderung zu entsprechen. Die Beobachtungen von Bulling in Reichenhall<sup>1)</sup>, dass tuberculöse Affectionen, mit Lösungen dieses Salzes behandelt, bedeutend reducirt wurden, ohne schlimme Nebenerscheinungen hervorzurufen, war der Grund, dass ich das Verhalten verschiedener Bacterienarten zu diesem Salze prüfte.

24 stündige Bacterienkulturen in Bouillon wurden mit der in Reagenzröhrchen enthaltenen sterilen Lösung von phenylpropionsaurem Natron von verschiedenen Concentrationen sehr rasch aber gründlich vermischt.<sup>2)</sup> Die so hergestellten leicht trüben Aufschwemmungen wurden nach gewissen Zeitintervallen in üblicher Weise mit Nährgelatine zu Platten in Petrischälchen verarbeitet. Diese Platten sowohl wie auch die Reagenzröhrchen, welche den Gelatinerest enthielten, wurden, wie sich von selbst versteht, vor Infection bewahrt. Die Kolonienzählung ergab die folgenden Ergebnisse :

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1). Münchner Medicin. Wochenschrift. 1904 u. 1905.

2). Diese und die folgende Operationen müssen möglichst schnell ausgeführt werden, sonst werden die Bacterien besonderes von stärkeren Lösungen jenes Salzes inzwischen zum Theil getödtet oder so geschwächt, dass sie nicht mehr sich entwickeln können.

TABELLE I.

Zahl der Kolonien<sup>1)</sup>

Bakterienarten	Gleich nach dem Mischen			Nach 3 Stunden			Nach 24 Stunden		
	1%	3%	5%	1%	3%	5%	1%	3%	5%
<i>Escherichia coli</i> ... ..	755	620	516	630	261	0	505	5	0
<i>Bacillus pyocyaneus</i> ... ..	696	630	320	510	4	0	260	0	0
„ <i>subtilis</i> ... ..	679	525	382	576	32	20	27	19	16
„ <i>typhi</i> ... ..	507	329	170	501	2	0	154	0	0
<i>Vibrio cholerae</i> ... ..	935	650	98	50	0	0	0	0	0

TABELLE II.

Zahl der Kolonien<sup>2)</sup>

Bakterienarten	Gleich nach dem Mischen		Nach 3 Stunden		Nach 24 Stunden	
	1%	3%	1%	3%	1%	3%
<i>Bacillus aerogenes</i> ... ..	372	165	369	0	356	0
„ <i>capsulatus</i> ... ..	412	130	109	0	23	0
„ <i>cyanogenus</i> ... ..	489	326		0	0	0
„ <i>denitrificans</i> ... ..	212	120	2	0	0	0
„ <i>flacherie d. Nonne</i> ... ..	184	262	2	2	0	0
„ <i>fluoresc. liquefaciens</i> ... ..	524	472	55	0	0	0
„ <i>mycoides</i> ... ..	247	256	208	237	276	193
„ <i>prodigiosus</i> ... ..	387	103	52	0	22	0
„ <i>typhi murium</i> ... ..	516	458	227	0	0	0
<i>Proteus mirabilis</i> ... ..	1153	1216	111	0	0	0
„ <i>vulgaris</i> ... ..	711	667	106	0	0	0

1). Die Zahlen repräsentieren den Durchschnitt von 4 parallelen Versuchen.

2). „ „ „ „ „ „ 3 „ „

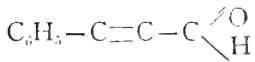


Das phenylpropionsäure Natron hatte also in 1 procentiger Lösung bei *Vibrio cholerae*, *Bacillus cyanogenus*, *B. capsulatus*, *B. denitrificans*, *B. flacherie* der Nonne *B. fluoresc. liquefaciens*, *Proteus mirabilis* und *Proteus vulgaris* eine stark bactericide Wirkung in 3 Stunden. *Bacterium coli*, *Bacillus pyocyaneus*, *B. typhi*, *B. aerogenes* und *B. typhi murium* sind gegen jene Concentration verhältnissmässig widerstandsfähig. In stärkeren Lösungen war die Wirkung natürlich grösser. Die Verminderung der Kolonienzahlen mit steigender Concentration der Lösung auf 3, resp 5% lässt erkennen, dass schon während der Herstellung der Aufschwemmung eine grosse Anzahl der eingetragenen Bakterien in der Regel vernichtet wurde. Sporenbildende Bakterienarten sind aber in Folge der Anwesenheit von Sporen selbst nach 24 stündiger Einwirkung einer 3 procentigen Lösung noch entwicklungsfähig. Bei *B. subtilis* war selbst nach 24 Stunden langer Einwirkung einer 5 procentigen Lösung dieses noch zu beobachten.

Ausser diesen Versuchen wurden noch andere angestellt mit weit verdünnten Lösungen der Natronsalze von Phenylpropion-, Zimmt- und Phenylpropionsäure. Hierbei ergab sich, dass eine 0.15 procentige Lösung des phenylpropionsäuren Salzes in Bouillon das Wachstum verschiedener Bakterien ebensowenig verhinderte als eine ebenso starke Lösung von zimmtsäurem Natron, dass beide diese Salze meistens aber etwas hemmend wirkten im Vergleich zum phenylelessäuren Natron. Die Wirkung des phenylpropionsäuren Natrons war sehr verschieden je nach Bakterienarten. So wirkte dieses Salz auf *B. aerogenes* und *Proteus vulgaris* mehr entwicklungshemmend als das zimmtsäure Natron; bei *B. subtilis* und *B. mesentericus vulgatus* war das Umgekehrte zu beobachten.

Die giftige Wirkung des phenylpropionsäuren Natrons beruht einerseits auf der Phenylgruppe, andererseits auf der dreifachen Bindung. Diese Giftwirkung musste noch erhöht werden, wenn statt der Carboxylgruppe eine Aldehydgruppe vorhanden ist.

$C_6H_5-CH_2-CH_2-COOH$	Phenylpropionsäure
$C_6H_5-CH=CH-COOH$	Zimmtsäure
$C_6H_5-C\equiv C-COOH$	Phenylpropionsäure



Phenylpropionaldehyd oder

Phenylpropargylaldehyd

Dieser Aldehyd<sup>1)</sup> ist aber einerseits sehr leicht veränderlich, er oxydiert sich leicht an der Luft, andererseits ist er so schwer in Wasser löslich, dass eine genaue Dosirung nicht gut möglich ist. Es ist nötig, zuerst eine alkoholische Lösung von bestimmtem Gehalt herzustellen und von dieser kleine Mengen zur Nährbouillon zu geben. Auf diese Weise konnte ich feststellen, dass eine 0,04 procentige Lösung dieses Aldehyds und des Zimmtaldehyds auf folgende Bakterien entwicklungshindernd wirkten: *B. capsulatus*, *B. cyanogenus*, *B. mesentericus ruber*, *B. mesentericus vulgatus*, *B. mycoides*, *B. prodigiosus*, *B. pyocyaneus*, *B. subtilis*, *B. typhi murium*, *B. Zopfii*, *Proteus vulgaris* und *P. Zenkeri*<sup>2)</sup> — Bei *B. aërogenes*, *B. erythrosporus*, *B. Megatherium*, *B. Plymouth* und *Sarcina aurantiaca* wurde jedoch die Entwicklung nicht verhindert.

Bei 0,03% war die bakterienfeindliche Wirkung jener Aldehyde schon weit schwächer.

1). Dieser Aldehyd wurde von zwei Jahren von *Chaisen* dargestellt, welcher die Güte hatte, uns eine Probe zu senden.

2). Bei den Controlversuchen mit der Bouillon unter Zusatz von gleichen Mengen von Aethylalkohol, als in den obigen Versuchen vorhanden war, zeigten diese Bakterienarten ein üppiges Wachstum

# Smut on Cultivated Large Bamboo (*Phyllostachys*).

BY

S. Hori.

## INTRODUCTION

In 1894, Mr. Y. Tanaka sent to me from the province of Mino some specimen of smutted branches of Hachiku-bamboo (*Phyllostachys puberula Munro*) inquiring after the nature of the disease and its prevention. As far as I know, the smut on bamboo has heretofore been not reported, neither in Japan nor elsewhere, and the specimen mentioned had been kept since in the herbarium of our Station bearing the unpublished herbarium name "*Cintractia Bambusae Miyabe et Hori*" as other work prevented me to investigate the matter. Since that time I received annually further specimens of branches attacked by the same disease not only on Hachiku-bamboo, but also on Madake-bamboo (*Phyllostachys bambusoides Sieb. et Zucc.*) from many of my friends and bamboo-growers from several provinces of Japan. I, myself had also occasion to observe the disease in several localities, especially in the warmer region of Japan.

The smut of bamboo is known by the local name of "Susu" (soot) among the bamboo-growers in the prov. Harima. It is also known by the name of "Jinengo" (wild rice) in the prov. Mino, as it resembles somewhat to the fructifying branches of bamboo, called also wild rice. This serious disease leads to the death of the entire bamboo forest. It is reported that the flowering of bamboo takes place after 60 years of existence and this is mentioned also in several Chinese and Japanese books of natural history and in monographs on bamboo; but we found nowhere an account about the smut

In 1900, Prof. Dr. P. Hennings\* of Berlin described a smut on a

\* P. Hennings, *Fungi japonici* I. Engler's Bot. Jahrbuch. 28 Bd. 3 Heft. 1900. p. 260.

Japanese wild low bamboo (*Sasa ramosa Makino et Shibata*) collected by Prof. Dr. M. Shirai in Nikko, and he gave the scientific name *Ustilago Shiraiana* as a new species; the descriptions is as follows:

Soris in ramis junioribus, eos deformantibus et incurvantibus, primo epidermide pallida tectis, dein pulverulentis, atro-olivaceis; sporis subglobosis v. ellipsoides, pallide olivaceis v. fuscis, levibus,  $4-7 \times 3\frac{1}{2}-6 \mu$ .

Hab. in ramis junioribus Bamboo Veitchii, Nikko Japoniae (Shirai)

By comparing the description of *U. Shiraiana Henn.* and the specimen *C. Bambusae Miyabe et Iiori*, they do not agree in regard to the shape and size of spores and in some other characters.

In the beginning of the last year, Dr. G. Yamada, professor of the Morioka Higher Agricultural and Dendrological School, kindly sent to me a good specimen of smut on wild low bamboo (*Sasa paniculata Makino et Shibata*) which bears the name of *U. Shiraiana*; and at almost the same time I received this same smut collected in the prov. Mutsu by Mr. N. Nambu. In May when I was travelling in the mountainous region of the prov. Kai, I also found fortunately the same smut on wild low bamboo (*Arundinaria Simoni Riv.* var. *Chino Makino et Shibata*.)

By comparing these three samples of smut and that on the cultivated large bamboo, it became clear that these smut fungi are quite similar, but they do not agree in the descriptions with *U. Shiraiana* on the points already mentioned.

Hence I consulted Prof. Dr. M. Shirai of the Agricultural College in the Imperial Tokyo University to get his original specimen of *U. Shiraiana* for deciding the question of what kind of Japanese bamboo smut Prof. P. Hennings described as *U. Shiraiana*

By comparing the smut fungi of the various kinds of bamboo at present in my hand, it appears that they are all identical, while at the same time, it became clear that in Hennings descriptions of *U. Shiraiana* there are some defects which undoubtedly are due to his observations on some old and dry specimens.

In Japan the several kinds of bamboo, both cultivated and wild, are of large economic use; hence the study of bamboo smut is of great importance.

The following contains the results of identification of smut fungi on cultivated large bamboo and *U. Shiraiana* together with the germination of spores.

#### SYMPTOMS OF THE DISEASE.

The disease always occurs on the younger internodes and growing points of branches, and it appears also that the disease may occur whenever the surrounding conditions be favorable from the time when the spring buds burst until the growth of the branches ceases. According to the degree of development of the branches when attacked, the symptoms of the disease are divided into two categories in which the extent of damage may naturally differ.

When the young short branches still covered by the leaf-sheathes and bracts, that is the elongated buds, be attacked, they assume at first a somewhat swollen and stouter form, and since no particular deformations or appearances externally are noticeable common observers will suspect no disease. (Pl. IX. fig. 1., Pl. XI. fig. 1.)

Such diseased branches seem generally to stop their further growth, while the smut fungus is continuing the spore formation. Finally the leaf-sheathes and bracts, the external coverings of the buds, begin to open and die off, and the smutted internodes and growing points covered with brownish powder of smut spores make their appearance from inside. (Pl. IX, X, XI. fig. 2.)

The smut is restricted to the internodes and growing points of young branches, and often on the lower part of the young leaf-sheath. By the slight prolongation of the infested internodes, the growing points and uppermost part of internodes are pushed upwards, while the latter are still covered closely by the bracts and leaf-sheaths. The affected parts become wrinkled or bent to one side showing numerous lateral folds

When most of the young branches are affected by the smut, the winter buds or undeveloped spring buds soon after begin to develop. In a certain stage of development, the numerous diseased and healthy branches crowded on certain spots of the old branches give the impression of hexenbesen.

Since this formation somewhat resembles flowered branches, it is mistaken by the growers as a sign of the "Jinengo-disease" (Pl. X. fig. 1)

The symptoms thus far mentioned are commonly observed on the young branches not more than 3 or 4 centimeters in length, which is the case in the latter part of May or the beginning of June, according to the temperature of the localities and the rain fall

As far as my observations go, the second new branches are commonly free from the smut, but they might possibly be affected by the disease also, if the surrounding conditions would be favorable, because the disease may occur late in July or even in August on the upper part of branches of considerable length; about the latter form of smut I will explain hereafter.

While short branches show the infection all over, the long branches show it only on the growing points and upper internodes, since their lower internodes have hardened; branches of 15—18 cm. length show this condition frequently, the lower 10—12 cm. being entirely free from smut (Pl. XI. fig. 3)

Such cases are commonly met with in July or August. The smut on wild low bamboo in most cases has the symptoms just mentioned (Pl. XI. fig. 3)

The deformations of the upper portion of the long branches resemble those of the young smutted branches. (The winter buds on unaffected internodes of branches smutted on the upper part are often accelerated in their development.)

Commonly the smut spreads over all of the branches of a single stock of bamboo and cases are not rare that a large forest is entirely infested. Sometimes, however, it is restricted to certain branches only and in some cases I observed, that the smut is restricted to the bamboo growing on the outskirts of a forest. When once the smut has invaded a forest, the disease will show more or less annually though the degree differs according to the weather

#### CONDITIONS FAVORABLE FOR THE DISEASE.

It is reasonable to suppose that the smut on bamboo had been present

more or less somewhere in Japan already at some remote time, though we can not find any record. It may also be possible that the smut formerly has been too rare to arouse the attention of the bamboo-growers until about ten years ago.

As a matter of fact the demand for bamboo is gradually increasing year after year for the manufactures of house utensils and other objects, for building materials of houses and fences, and it is also largely used for the protection of river banks. This increased demand for bamboo has induced the culture of bamboo forest everywhere and the growers pay now much more attention to their bamboo forests than formerly, which is also the reason why the occurrence of the smut is reported by many growers. Secondly, the increase of bamboo forests facilitates again the spreading of the smut fungi.

According to the symptoms of the disease, the occurrence of smut has a close relation to the rain fall and wind at the time of the development of the attacked branches. The restriction of smut to the upper part of the longer branches shows really such a relation.

Though my observations were limited to some localities, the following facts may also prove this. In 1902, the rain fall had continued about three weeks between May and June; so that I had postponed my departure until the 5th of June. During this journey lasting four weeks in the prov. Omi, Bizen, Aki and Sanuki, I have met with severely smutted bamboo forests everywhere

The wind is a principal factor of transporting the spores for the propagation of and natural infection by the smut. Since the branches of bamboo growing on the outside of the forest are much more smutted than the inner, a relation to the wind becomes evident

The relations to manuring and to the influence of the moisture of the soil are not yet clear. The bamboo growing on unmanured dry sandy banks of rivers or on hill-sides are just as well attacked, as that growing on fertile soil.

#### DAMAGES AND DISTRIBUTION.

When most of the young branches are severely attacked by the smut,

the growth of the bamboo stocks is greatly disturbed and death results. The affected stems became brittle whereby the value is greatly reduced, or the stems may even become entirely useless for certain purposes. The smut disease of bamboo causes therefore great damage to the growers who are as much afraid of this dreadful plague as of the flowering of the bamboo, which also causes the death of the plants.

But when the upper elongated branches alone are attacked the effect on the further life of the bamboo is not directly perceivable.

The smut has been found on several kinds of bamboo, both cultivated and wild, throughout the empire. In the warmer regions where the large bamboo (*Phyllostachys*) is widely cultivated, the smut is found only on cultivated bamboo, and was not yet found on wild bamboo; while in the northern cold climate, the smut occurs merely on wild low bamboo.

At present, the smut is known to occur on the following four species of bamboo, namely, *Phyllostachys bambusoides* *Sieb. et Zucc.*, *P. puberula* *Munro*, *Sasa ramosa* *Makino et Shibata* and *Arundinaria Simoni Riv.* var. *Chino* *Mikino et Shibata*; the former two species are cultivated and thrive well in the warmer region, while the latter two species are entirely wild low bamboo, growing on road side or hills in the northern regions.

It is peculiar that the smut is not yet found on Moso bamboo (*Phyllostachys mitis Riv.*) though the allied species of Hachiku and Madake-bamboo are largely cultivated side by side with the latter.

I fear the smut would some day in future be found also on the Moso bamboo and also on numerous other wild species.

#### SMUT FUNGI.

The smut fungus after penetrating into the tissues of the growing points, internodes and also the lower part of leaf-sheath of the young branches, begins to form the spores on their surface; by the gradual increase in number and the maturation of the spores, the leaf-sheath and bracts which still cover closely the outer part of the affected branches are pushed out and in opening widely the deep brownish spore-masses are brought to light.



In scraping off the leaf-sheath and bracts of the affected branches in the earlier stage in which practically no external particular appearance of disease is noticed, we can perceive the faintly brown colored surface, with here and there some small brown spots, of the growing points and internodes. These brown spots are the portions where the spores matured a little earlier than on others.

A cross section of the affected internodes under the microscope shows the presence of mycelium running throughout the tissue, and on the surface of the internodes the spores of different size and color are seen in chain-like arrangement. It is of special importance to notice that the ruptured epidermis of the host in the smutted part is not perceivable, though Prof. Dr. P. Hennings wrote "Primo epidermide pallide tectis" in his description

Indeed, the epidermis of the host when infested by the smut fungus is very young and not yet fully differentiated. Hennings so called overlapping epidermis are no doubt, the dead leaf-sheath and bracts and not the true epidermis of the host

The matured spore-masses are deep brown in color and light and pulverulent in texture. The spores are easily blown away by the wind or washed down by the rain, after the coverings of the bracts are opened.

Under the microscope the spores appear mostly spherical, sometimes subglobose or elliptical, and they are almost uniform in the shape in different specimens; light olivaceous or sometimes light brown in color; contents finely granular with often one or two oil globules at the center; epispore rather thin and smooth,  $5.5-11=5.5-12 \mu$  large, but  $6-9=6-10 \mu$  is the most common size.

About the shape and size of spores, my observation differs somewhat from that of Prof. P. Hennings. But this contradiction was fully solved after my observation on the Hennings original specimen, which Prof. M. Shirai kindly sent to me for comparison, and the fresh specimen of the same smut fungus on the same host. It has become clear that Hennings has observed

the smut of a comparatively old dry specimen in which the spores were mostly shrunk and reduced in size.

In fresh or comparatively recent specimen, the spores are mostly spherical and those of subglobose or elliptical form as Hennings described, are rather rare. The spores commonly attain the size of about  $6-9=6-10 \mu$ ; hence they are much larger than those described by Hennings, while in general the smut spores on *Phyllostachys* are comparatively larger than that on *Sasa* and *Arundinaria*. The latter fact is a common phenomenon on the numerous other parasitic fungi and it is of no value for separating the species on the systematic standpoint, because the other characters viz. shape, color, germination etc. are quite similar.

The following is the measurement of the size of the spores taken at random from the different specimen and the host.

Specimen.	Size of the spores in $\mu$ .		
	7×7	6×6	6×6
	7×7	8×9	7×9
	7×7	6×8	8×8
	8×8	7×7	6×7
	6×6	7×8	6×6
On <i>Arundinaria</i> Shimoni <i>Kii</i> .	7×8	8×8	7×7
var. <i>Chino</i> Mak. et Shib., Prov.	8×10	8×8	6×6
Yamanashi, (S. Hori).	6×6	8×8	8×8
	7×8	6×6	7×8
	6×7	6×7	8×8
	8×8	7×8	6×7
	6×6	8×8	6×7
	7×7	6×6	8×9

Specimen.	Size of the spores in $\mu$ .		
On <i>Sasa ramosa</i> Mak. et Shib., Prov. Aomori (N. Nambu).	6×7	7×8	8×8
	7×7	7×8	7×7
	7×7	6×6	6×6
	8×8	8×8	8×8
	7×7	7×7	6×7
	7×8	8×8	7×8
	6×6	6×7	7×7
	6×6	7×7	6×6
	5.5×6	7×8	8×8
	6×6	8×8	8×8
	7×7	6×6	9×9
	7×8	7×7	6×6
	7×7	8×8	6×6
On <i>Sasa ramosa</i> , Prov. Morioka (G. Yamada).	7×8	6×6	7×7
	8×8	6×6	6×8
	6×7	6×6	6×6
	7×7	8×8	5.5×7
	6×6	5.5×5.5	7×7
	7×8	8×8	8×8
	7×8	7×8	7×8
	6×8	8×8	6×7
	6×6	8×9	6×8
	8×8	6×6	7×8
8×8	6×6	8×8	
7×8	8×8	6×6	

Specimen.	Size of the spores in $\mu$ .		
On <i>Phyllostachys puberula</i> <i>Munro</i> , Prov. Mino, (Y. Tanaka).	8×8	9×9	9×9
	9×9	8×8	7×8
	7×8	9×9	8×8
	7×8	9×9	8×8
	8×8	9×9	9×9
	8×8.5	7×8	7×8
	9×9	7×8	8×9
Yamato specimen (B. Nakano).	8×10	10×10	10×10
	6×7	10×10	9×10
	9×9	8×9	9×10
	10×10	8×10	8×8
	8×8	9×9	8×9
	10×10	7×8	9×9
	7×8	7×8	10×10
	8×9	9×9	10×10
Tokio specimen (T. Makino).	8×9	8×8	6×9
	7×7	8×9	7×8
	7×7	9×9	8×8
	8×8	8×8	8×8
	8×8	8×8	8×9
	6×7	6×7	8×8
	8×8	6×7	7×8
Tokio specimen (S. Hori).	8×10	10×10	8×9
	8×8	10×10	9×9
	9×9	9×10	9×10
	7×10	9×9	8×8
	8×8	9×11	10×10
	10×10	9×9	8×8
	8×9	8×8	8×9

Specimen.	Size of the spores in $\mu$ .		
Yamato specimen,* (T. Jinno).	11×11	9×9	10×10
	10×11	10×10	10×10
	8×10	8×9	10×10
	10×10	8×8	10×10
	10×10	8×9	10×11
	10×10	10×10	10×12
	10×10	10×10	8×9
On <i>Ph. bambusoides</i> Sieb et <i>Zucc.</i> , Prov. Harima, (K. Watanabe).	8×8	9×9	8×8
	8×9	9×9	6×7
	6×7	9×9	9×9
	8×8	7×8	9×9
	10×10	7×7	8×9
	7×7	10×10	7×7
	8×8	7×7	6×7
7×8	9×10	8×9	
Kaga specimen (R. Taniguchi).	8×9	9×9	8×8
	8×9	7×8	8×8
	8×9	9×9	8×8
	8×9	8×8	8×9
	7×8	8×8	8×9
	8×8	9×9	8×9
	7×8	8×10	9×9
	8×9	8×8	9×10

## GERMINATION OF SPORES.

Before entering into the details of the germination of the spores, it is important to notice the methods of culture carried on. The materials were always chosen from the fresh specimen, and the spores for germination were

\* In this specimen spores are much larger and pale olivaceous in color.

taken by means of a sterilized platinum needle from the smutted portion of bamboo branches, where the spore-masses were still covered by the leaf-sheath, in order to avoid the admixture of foreign impurities. By this precaution, I have succeeded in most cases in the culture of the spores in an almost pure condition.

For the germination of the spores, I have used the hanging drop culture with the Van Tieghem cell of  $\frac{1}{2}$  cm. high and  $1\frac{1}{2}$  cm. of inner diameter, and the slide of the hollow place at the center. The cells and slides were sterilized previously and the former was fastened to the latter by vaseline.

The sterilized distilled water used for the germination of the spores was dropped on the surface of the sterilized cover glass by means of a platinum needle, and after the spores were sown into the water, the cover glass was kept inverted over the cell to which it was fastened with vaseline. But in most cases the spores were not sown directly into the water, they were first sown thinly on the dry surface of a cover glass, and the latter was then inverted over the cell into which a few drops of water previously were poured. After a few hours some vapour condenses on the spores of the cover glass, and thus almost the same condition was reached as in directly sowing the spores into the water. Indeed, for the continued observation on the growth of certain spores, the latter method is of much more convenience.

As a culture medium a 20 % solution of the Japanese ame\* was principally used. The bouillon sometimes used was prepared after the formula ordinarily followed by bacteriologists; but it accelerated the growth of bacteria and greatly retarded the germination of the smut spores. Aside from this defect there was no apparent advantage compared with the ame solution. The modified Cohn solution was also used, but the result was practically the same as with the ame-solution.

Throughout the work the greatest care was taken to preserve the cultures free from contamination of any sort. Unless otherwise stated, the cultures were kept in a light-proof thermostat at a temperature of  $25^{\circ} \pm C$ .

Germination in water: the fresh spores germinate readily within 10 hours, a spindle shaped promycelium protruding, which when attaining the

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\* Ame is a transparent semi-fluid of sweet taste made from malt and rice or millet.

full growth, becomes a single septated long spindle or cylindrical form  $3\frac{1}{2} \mu$  in breadth and 20—22  $\mu$  in length with numerous vacuoles, and the lower younger portion of the promycelium forms what Brefeld calls a knee to which the upper portion of the promycelium is attached. Rarely the secondary promycelium is protruding from one side of the knee; it finally attains the same form as the primary promycelium.

The detached promycelium produces one or two sporidia at the septum or the end, which may be detached or not and will develop to the same form as the primary promycelium; but in the most cases, the sporidia are developed into the slender long hypha.

Germination in a nutrient solution: almost the entire number of the spores sown have germinated within a few hours and each produces a long spindle or cylindrical promycelium which apparently does not differ in shape from that formed in water. But the germination of spores in a nutrient solution compared with water, is far more vigorous and luxuriant, and the full grown promycelium attains 3—5  $\mu$  in width and 20—36  $\mu$  in length, commonly 4 and 28  $\mu$ .

In 20—24 hours, while the primary promycelium still is attached to the knee, the secondary promycelium begins to make its growth from the knee, and in the next 24 hours both, the primary and the secondary promycelium, are septated by one or two cross partitions, and often a third promycelium is produced. The full grown promycelium is easily detached and produces sporidia on the apex or near the septum. Often two continuous segments of a detached promycelium may become united by the knee-joint fusion which finally produces one sporidium after developing to some length.

When the detached promycelium is removed into a fresh nutrient solution, it makes a more vigorous growth, increasing in length and breadth, and forming many septa. In this case mostly 3 sporidia are produced directly at the end, and directly or indirectly by a kind of sterigma at the septa. These sporidia soon develop again into the ordinary form of septated promycelium, and the latter being easily detached repeats the growth as above described when the nutrients in the culture medium are not exhausted or when they are removed into a fresh nutrient solution.

Throughout the numerous culture experiments with both water and nutrient solution, the formation of aërial conidia has not been observed.

Though it is not yet shown experimentally in what way the infection by the present smut fungus takes place, it might be possible to consider that the sporidia produced on the promycelium of the spore, which escaped by the wind or the rain from the smutted branches in the preceeding season or year into the ground in the vicinity of the bamboo forest, are brought in contact with the young soft branches by the wind, and after obtaining the proper moisture, the germinated sporidia make their entrance into the soft tissues of the branches by means of the germ-tube.

From the mode of germination of the spores, it appears that the present smut fungus belongs decidedly to the *Hemiustilago* Brefeld.\*

As a result of the study of this smut fungus, we are forced to make some changes in the original description of *Ustilago Shiraiana* Henn, as follows :

*USTILAGO SHIRAIANA* P. Henn.

Fungi jap. I. Engler's Bot. Jahrbüch. 28 Bd. 3 Heft. p. 260. 1900; Sacc. Syll. Fung. XVI. pars V. p. 369. 1902; Ideta Lehrbuch. d. Pflanzenkrankh. (japanisch) p. 156. 1903; Omori et Yamada Pflanzenpath. (japanisch) p. 251. 1904.

Produced on the growing points and internodes of the young branches, causing often deformation or distortion; spore-masses at first covered by the leaf-sheath and bracts, pulverulent, deep brown; spores spherical, sometimes subglobose or elliptical, the rounded ones 6—10  $\mu$  in diameter, and the elongated ones 5.5—10=6—12  $\mu$ . in size.

Epispore light olivaceous, smooth; contents finely granular with some oil globules; promycelium cylindrical or long fusiform, pedicellated, 1—2 septated, evanescent; sporidia terminal and lateral, long fusiform or elliptical, develop into the new promycelium.

Hab. on *Phyllostachys puberula* Munro Prov. Musashi (T. Makino May 1894), Prov. Mino (Y. Tanaka July 1894), Prov. Harima (K. Watanabe May

\* Brefeld, Untersuch. a. d. Gesam. mt. d. Myk. XII Heft, p. 218. 1895.



1900), Prov. Idzumo (F. Tanaka June 1900), Prov. Harima (K. Watanabe May 1901), Prov. Idzumo (F. Tanaka May 1902), Prov. Bingo (S. Hori June 1902), Prov. Yamato (S. Nakano July 1902), Prov. Bitchu (Z. Shō July 1902), Prov. Idzumi (reg? June 1904); *Ph. bambusoides Sieb. et Zucc.* Prov. Yamato (T. Jinno July 1897), Prov. Harima (K. Watanabe May 1900), Prov. Kaga (R. Taniguchi June 1900), Prov. Musashi (S. Hori August 1900), Prov. Sanuki (S. Hori June 1902), Prov. Awa (S. Hori June 1904); *Sasa ramosa Makino et Shibata* Nikko Prov. Shimotsuke (M. Shirai June 1899), Prov. Rikuchu (G. Yamada June 1903), Prov. Mutsu (N. Nambu June 1903); *Arundinaria Simoni Riv. var. Chino Makino et Shibata* Prov. Kai (S. Hori May 1904), Prov. Musashi (N. Nambu May 1904).

#### PREVENTION.

It is a matter of high importance that the smutted branches which are still covered by the leaf-sheath, that is before the spore-masses are scattered away by the opening of the leaf-sheath, should be cut off and burnt. The continuous careful removal of the immature smutted branches may possibly reduce the damages.

Since the smut on *Sasa* and *Arundinaria* growing on the road sides or hills and that on the cultivated *Phyllostachys* is identical, it is also important to take off the smutted branches on *Sasa* and *Arundinaria* growing near the vicinity of a *Phyllostachys* forest.

Spraying with Bordeaux mixture, at the time when the spring buds just begin to develop, should be beneficial. Sprinkling of lime on the ground of the bamboo forests after clearing it from the defoliated leaves just before the spring buds burst, should also be effectual to some extent.

I am indebted to Mr. T. Makino for the identification of the species of bamboo prepared to the specimen, and to Prof. Dr. M. Shirai, Dr. G. Yamada, and Mr. N. Nambu and many others for kindly supplying me with the specimens.

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## EXPLANATION OF FIGURES.

## PLATE IX.

- Fig. 1. Earlier stage of the smutted branches of *Phyllostachys puberula* *Munro* still covered by the leaf-sheathes and bracts. The specimen collected by Mr. T. Makino May 6, 1894 at the vicinity of Tokio.
- Fig. 2. Later stage of the severely smutted branches of *Ph. puberula* *Munro*. Osaka specimen collected June 13, 1904.

## PLATE X.

- Fig. 1. Smutted and flowered branchlets on the same branch of *Ph. bambusoides* *Sieb et Zucc.* The specimen collected by Mr. K. Watanabe May 20, 1900 in the Prov. Harima.
- Fig. 2. Smutted branches of *Sasa ramosa* *Mak. et Shib.* The specimen collected by Dr. G. Yamada June 21, 1903 at Morioka in the Prov. Rikuchiu.

## PLATE XI.

- Fig. 1. Earlier stage of the smutted spring branches of *Ph. puberula* *Munro*; the spore-masses are still covered by the leaf-sheathes and bracts.
- Fig. 2. Later stage of the smutted spring branches of *Ph. puberula*; the spore-masses on the internodes are brought in sight by the opening of the leaf-sheathes and bracts.
- Fig. 3. Long branches of *Ph. bambusoides* *Sieb et Zucc.* smutted only on their upper portions showing that the disease occurred late in the season.

## PLATE XII.

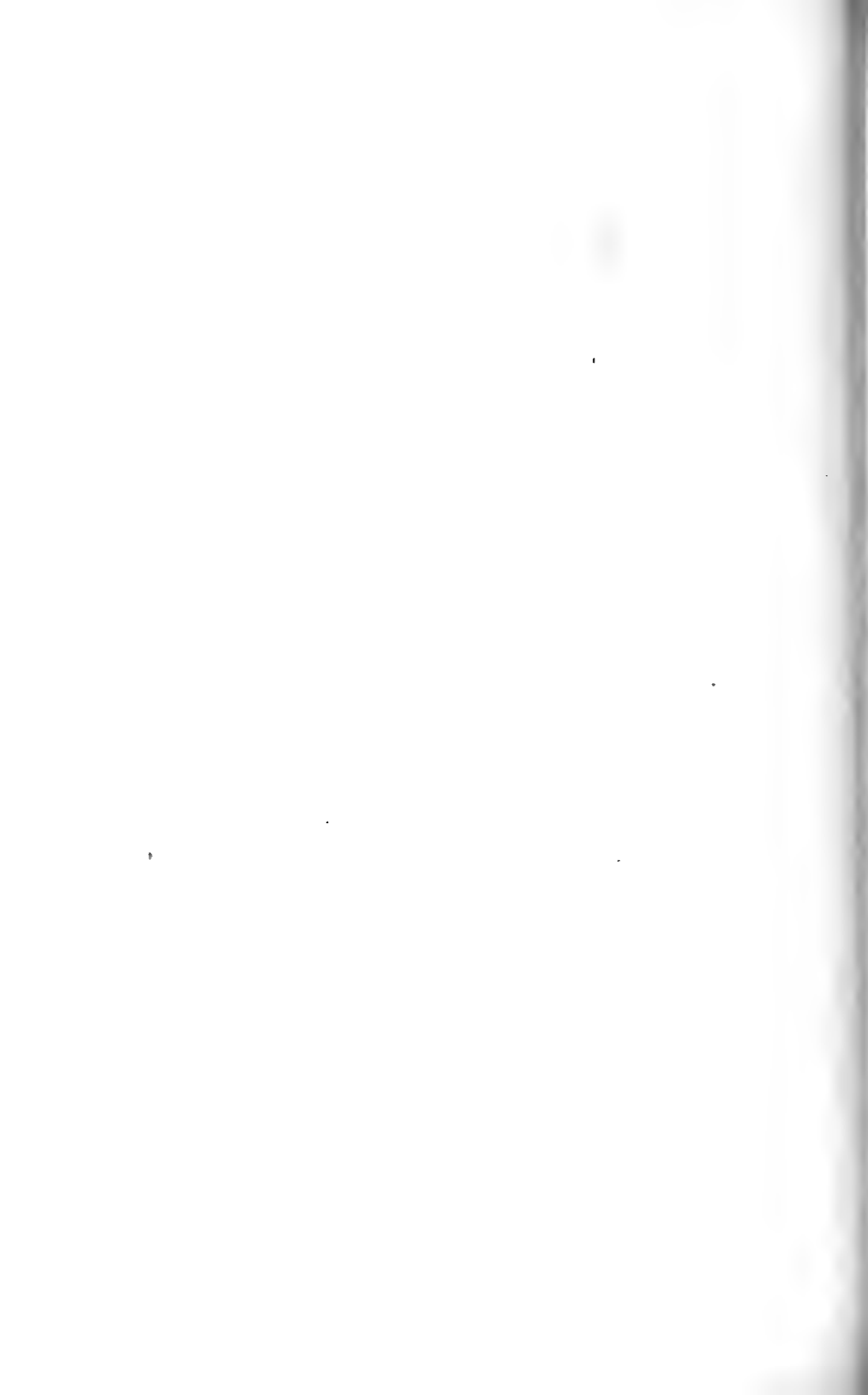
- Fig. 1. Germination of the spore in water observed continuously after 12-20 hours. (Zeiss F  $\times 4$ ).

1



2

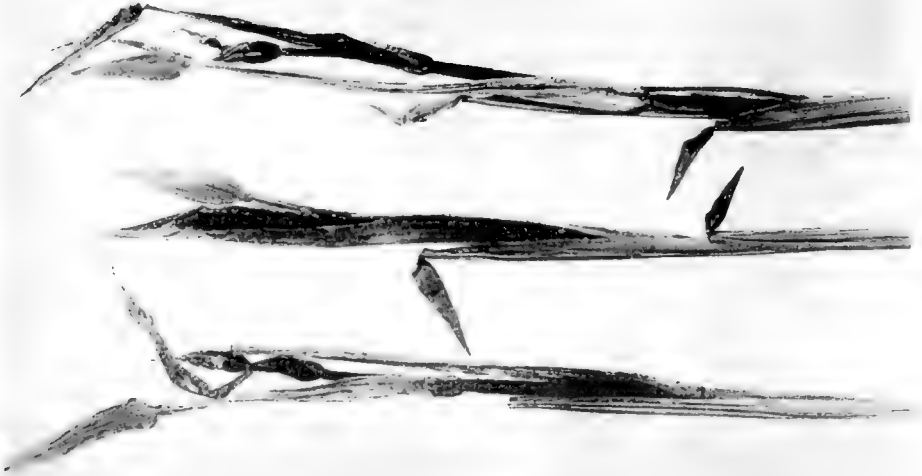


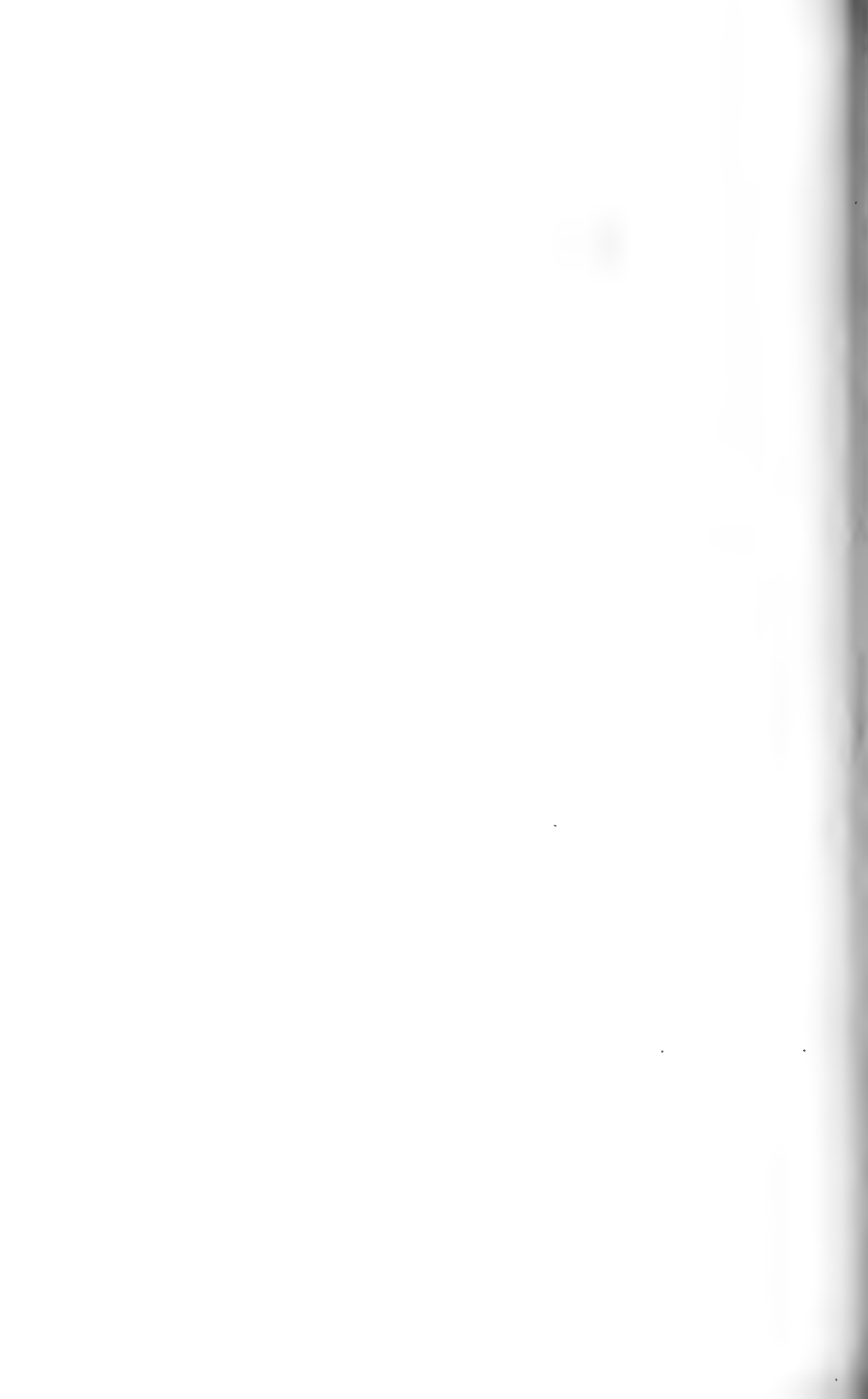


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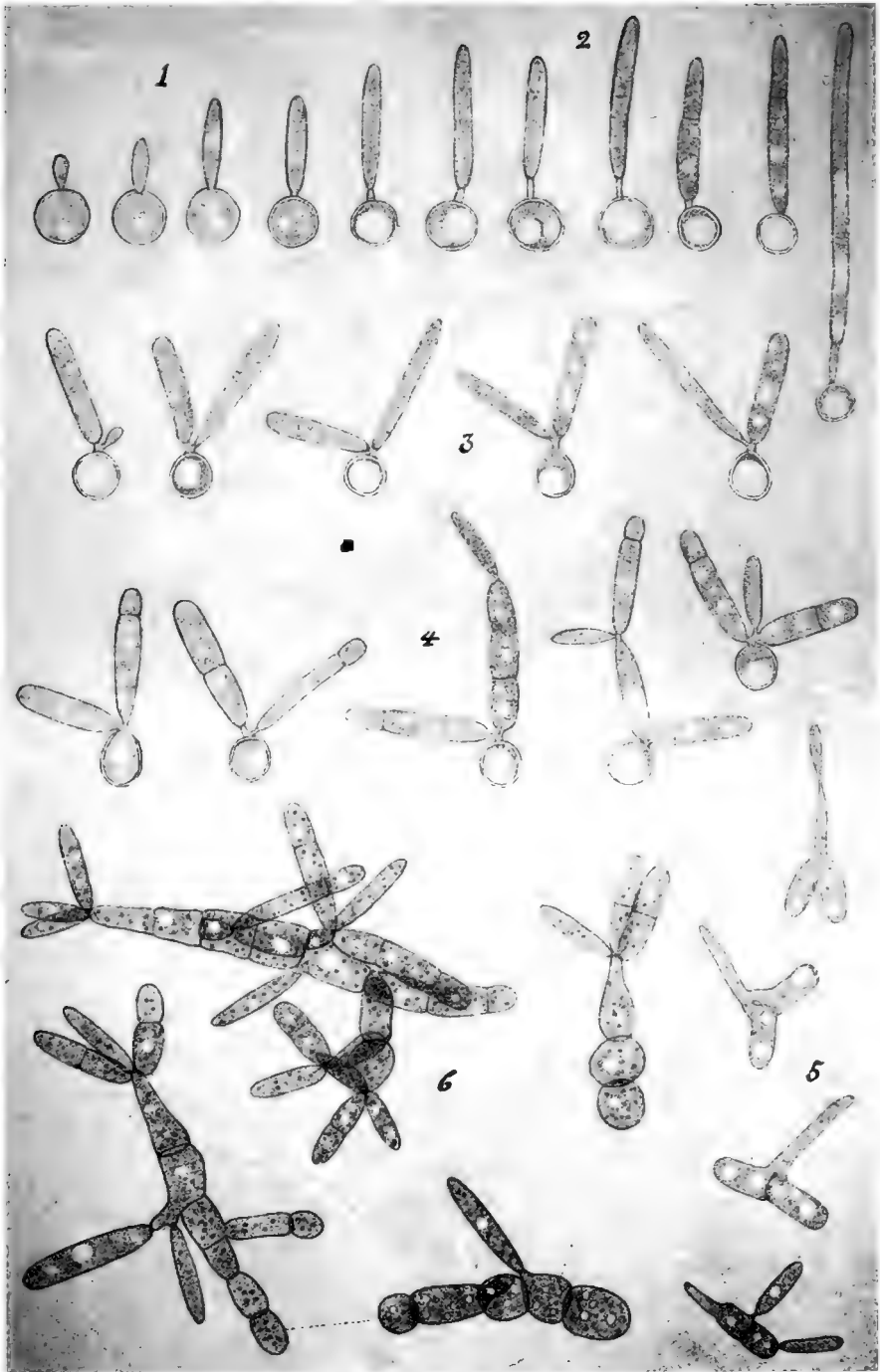




S. Hori del.

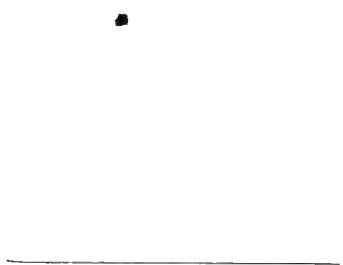






S. Hori del.



- Fig. 2. Germination of the spores in water after 24 hours. Promycelia pedicellated and some of them are 1-septated. (Zeiss F  $\times$  4).
- Fig. 3. Germinated spores in ame-solution after 24 hours. Secondary promycelia produced are still attached. (Zeiss F  $\times$  4).
- Fig. 4. Same culture as above after 48 hours. (Zeiss F  $\times$  4).
- Fig. 5. Detached promycelia in ame-solution produced the sporidia directly or by the knee-joint fusion after 48 hours. (Zeiss F  $\times$  4).
- Fig. 6 Detached promycelia cultured in the fresh ame-solution observed after 4 days.
- 

## On a Crane Fly (*Tipula parva*?).

(*Inc-no-Kiriusi*.)

BY

S. ONUKI.

Introduction :—Larvae of the *Tipula* or Crane-flies often cause considerable damage to pastures and farm crops in England and other European countries. They live generally in hedges and weedy banks and are also found among rotten vegetable matter, roots of grasses and other garden and farm crops. The most favorable places for this insect are however damp meadows and marshes.

In Japan, a species of crane-fly, *Tipula parva* (?) which I intend to describe in the following lines, is most widely spread and represents one of the worst pests of the rice plants, especially when the latter are still in the seed bed. In the spring the larvae destroy rice seedlings in the bed, by burrowing in the soil and gnawing the young plants or attacking the grains, before germination. In some parts of this country, very often sixty to ninety per cents of the seedlings are thus destroyed. They are, however, not only injurious to the rice crop, but also, to some extent, to wheat and barley in the fall, by eating through the stalk, just beneath the surface of the soil.

On account of the peculiarity of their habits and of the structure of the larvae, they can well resist insecticides and different climatical influences. Hence attempts to exterminate them are often rendered futile.

Life history :—There are two generations in one year. The adult flies of the first brood appear about in April. The females lay their eggs within a week on the wet ground. The eggs hatch in two weeks, and the larvae feed upon young rice plants and decaying organic matter in the seed bed. The larvae are changed into pupae in the month of August, and finally the adult insects appear in September. This is the adult of the second brood. As in the first, the females soon lay eggs, and the larvae which hatch from

the eggs feed upon roots of the winter crops—wheat and barley, and damage them. The offspring of the fall-flies remain in the larval stage through the winter and become adults in the following April.

In April 1st 1903, I collected a large number of full grown larvae from the experimental field of our station, and kept them in our insectory to study the life history. The result is as follow :

1903 April 1.	Full grown larva.	
" " 4.	Pupated.	
" " 17.	Adults emerged.	Pupal stage 14 days.
" " 19.	Females laid eggs.	
" May 1.	Larvae hatched.	Egg stage 12 days
" Aug. 25.	Pupated.	Larval stage 116 days.
" Sep. 3.	Adults emerged.	Pupal stage 9 days.
" " 5.	Females laid eggs.	
" " 11.	Larvae hatched.	Egg stage 6 days.
1904 April 4.	Pupated.	Larval stage 235 days.
" " 14.	Adults emerged.	Pupal stage 10 days.
" " 17.	Females laid eggs.	
" " 29.	Larvae hatched.	Egg stage 12 days.

The adult insects appear mostly in the morning, between 8 and 10 o'clock. The flies come out from the T shaped splitting in the dorsal part of the pupae, and keep themselves quiet for a short time, in order to dry their wings and harden their limbs, before they take flight. In the field the development is not so regular and the adult insects are seen throughout the whole spring and in the first part of the summer, although they are most abundantly found in April. In the field the larvae of different stages are seen almost at any time, hence it is very difficult to state in which generation they belong.

Description :—

Adult : ♀ length 20 mm., expansion of the wings 43 mm., ♂ length 17 mm., expansion of the wings 41 mm. Large, slender fly with very long,

slender legs. General color pale brown. Head spherical, face produced, snout-like. Eyes round and black, separated by a broad front. Ocelli wanting, antennae long, thread-like, composed of thirteen segments, flagellum in form; first three segments pale brown, while other dark brown; second segments shortest, first and third segments large and longest, other subequal; first, second and third segments bear many short bristly hairs, while others with few short bristly hairs at the base. Proboscis elongated; palpi, almost as long as the length of antenna; bear many short hairs; composed of four segments; the basal segment shortest, the second and third segments almost twice as long as the first, fourth segment longest; larger than other three segments together. Thorax convex; metanotum with distinct suture of V shape, dark brown color; prescutum with seven dark brown straight lines; scutellum small and semicircular. Abdomen cylindrical, ten segmented; dorsal aspect yellowish brown, with darkish brown toward lateral aspect; in the female, the ovipositor with two pairs of long, horny, pointed valves. Wings long, but comparatively narrow; when rest lying not parallel over the abdomen; brownish color, costal region and stigate dark brown; balancers very large. Legs very slender, about  $1\frac{1}{2}$ —2 times as long as whole length of the body; dark brown in color.

Egg: Length about 1 mm.; shiny black; elliptical in outline and flat. A long, slender, thread-like appendage at one extremity and with a small conical projection at the lateral side of other extremity.

Larva: Length about 26 mm., greatest diameter about 4 mm.; cylindric; dusky brown. Head small, retracted; two strong chitinous plates which correspond to mandibles of other insects are well formed, bear many fine teeth. Antennae small, composed of three segments, third segment shortest. On the dorsal aspect of the body with four rows of longitudinal black doty lines; ventral aspect with a pair of black spots on each segment, excepting last three segments. Abdomen is without any tubercles, spines or hairs. Anal prominence pale yellowish, bearing at its sides three pairs of similar equal appendages which are blunt at the apex. The respiratory disk bears three pairs of marginal lobes and, between the base of the lowermost and the anal prominence, a conspicuous, setigerous tubercle. The six

marginal lobes are short and blunt at the apex, two pairs of them with a black line extends up the posterior face.

**Pupa:** Length about 23 mm., horns about 1.5 mm., diameter about 4 mm at thorax; dark brown in color, more or less darkening toward sides. Head and face directed ventrally. The hypertrophied and functionless respiratory horns are large and rather stout, slightly enlarged at the apex. Antennae curve dorsally around the eyes and knees reaching to about one third of the whole length of the wings. Legs laid flat against the ventral surface, tips of the tarsi all ending near the apex of the fourth abdominal segment. Wing tips reaching to third abdominal segment. Abdomen with parallel sides, as far as the eighth segment. The apical carina on each segment is fringed with short, stiff hairs. The rudiments of the discal processes and the atrophied spiracles are distinctly seen on the dorsum of the eighth segment.

**Notes on Treatment:**—The experiments made in the laboratory as well as on a large rice field and seed bed show that larvae can not exist in water for a long time.

The writer had in the past year the opportunity of destroying the larvae in Saitama-ken, where they appeared in enormous number and made a great damage in the seed bed. In order to destroy the insects the water was allowed to flow in the seed-beds to the depth of two inches and kept for 6 to 36 hours according to the size of the seed-beds. A careful observation showed that nearly all of the larvae came out from the bed to the dikes. In order to prevent the larvae from creeping back again to the seed bed a ditch of about one foot in depth and width was dug in the seed bed along the dike and the water was allowed to flow into it. The larvae were then collected and destroyed.

This method is the easiest and cheapest, yet very effective.

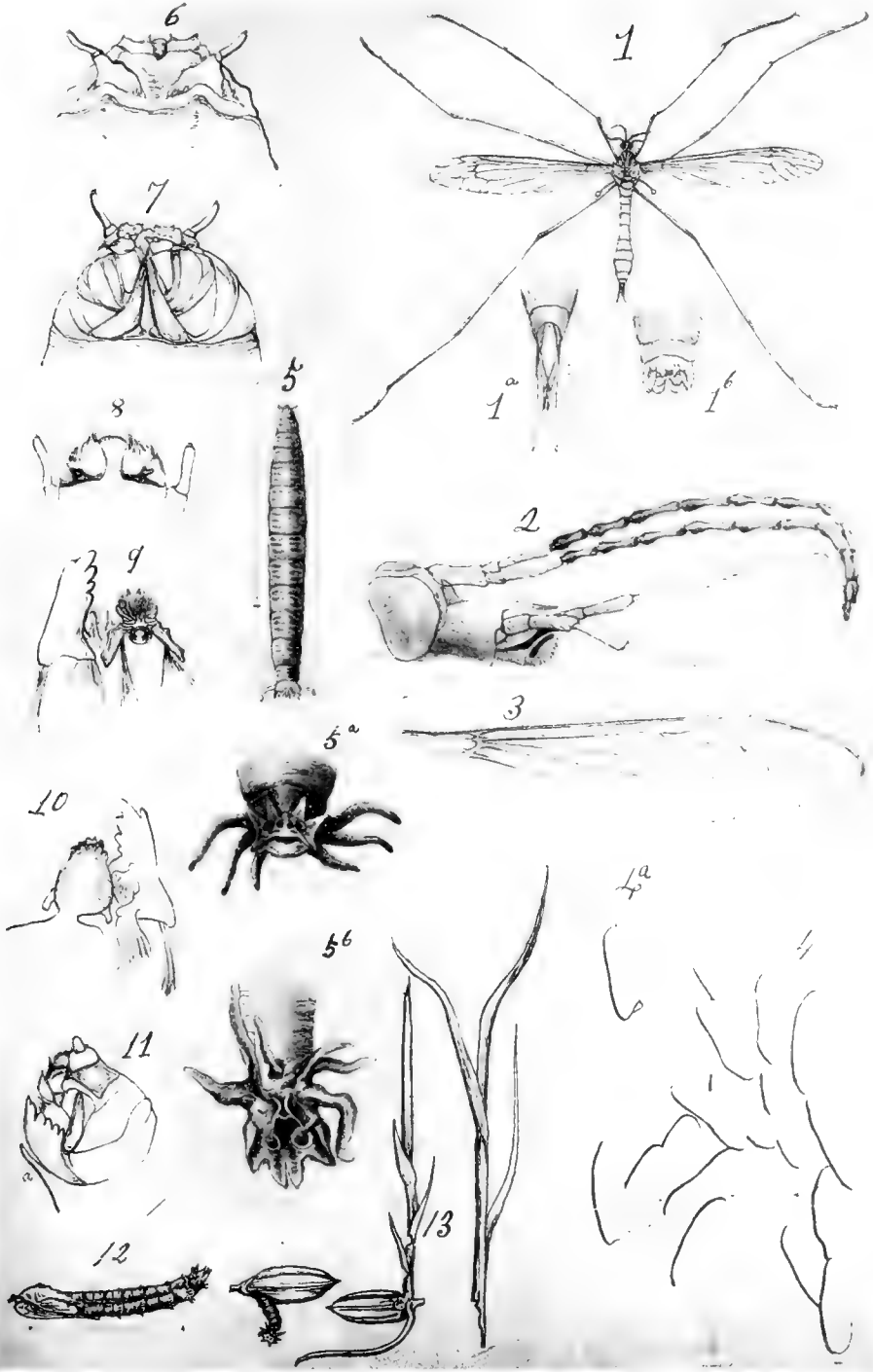
Some experiments with kerosene emulsion and Pyrethrum powder were also made, but with the former the young plants themselves suffered, while with the latter, the insects were not seriously affected.

Besides a deep plowing of the soil in winter also the catching of the adult insects with lanterns should not be neglected

## EXPLANATION OF PLATE XIII.

- Fig. 1. Imago (♀) (*Tipula parva* Loew?).
- Fig. 1<sup>a</sup>. Abdominal extremities of the female.
- Fig. 1<sup>b</sup>. " " of the male.
- Fig. 2. Head (showing antennae and pulpi).
- Fig. 3. Wing (showing venation).
- Fig. 4. Egg cluster.
- Fig. 4<sup>a</sup>. Egg.
- Fig. 5. Larva.
- Fig. 5<sup>a</sup>. Abdominal extremities of the larva (dorsal view)
- Fig. 5<sup>b</sup>. " " " " " (ventral view).
- Fig. 6. Head of larva (dorsal view)
- Fig. 7. " " " (ventral view).
- Fig. 8. Labrum.
- Fig. 9. Mandibles (showing pharynx; frontal view)
- Fig. 10. " ( " " back view).
- Fig. 11. Maxillary and labium (a. labium), right side.
- Fig. 12. Pupa.
- Fig. 13. Damaged rice plants.
-







明治三十八年十一月二十六日印刷

明治三十八年十二月一日發行

# 農事試驗場

東京市日本橋區兜町二番地

印刷者 金澤求也

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印刷所 東京印刷株式會社



## ERRATA.

Page 8, Line 30...	FOR "Ca (PO <sub>4</sub> ) <sub>2</sub> "	READ "Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> "
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" 41, " 20...	" "anschneidet,"	" "anschneidet "
" 47, " 19...	" "ab "	" "auf "
" " " 25...	" "Wachstum Bacillus,"	" "Wachstum des Bacillus"
" 48, " 24...	" "order "	" "oder "
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" " " 19...	" "Mg SO <sub>4</sub> 3% "	" "Mg SO <sub>4</sub> 0.3% "
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" 65, " 19..	" "Bakterium Monache "	" "Bakterium Monachae "
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" 84, " 21...	" "20 %,"	" "10 %"

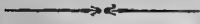


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農事試驗場歐文報告

第一卷第二號



THE

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Vol. I. No. 2.



NISHIGAHARA, TOKIO. OCTOBER, 1907.

## ERRATA.

Page 24	line 4	from top;	For acidulating	read neutralizing.
" 40	" 2	" "	" Sweidish	" Swedish.
" 52	foot note;		" principals	" principles.
" 55	bottom line;		" reduced	" reduced to.
" 60	line 3	from below;	" 18.85	" 188.0.
" 71	" 17	from top;	" 17.58	" 17.48.
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" 94	" 13	" "	" sulphate <sup>1</sup> )	" sulphate.
" "	" 7	" "	" sulphate	" sulphate <sup>2</sup> ).
" 105	" 7	" "	" of barley	" barley.
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" 117	" 5	from top;	" 7.8	" 8.8.
" 119	" 7	from below;	" IV	" VI.
" 187	" 6	" "	" Figs. 45-54	" Figs. 48-54.
" 231:	For Plate XXXVI, Fig. 1; read Plate XXXV, Fig. 13.			
Plate XXXI; For 49 (Leq. read 47).				



農事試驗場歐文報告

第一卷第二號



THE

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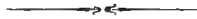
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## On the Formation of Flowers after Frost.

BY

G. DAIKUHARA.

A very singular phenomenon was observed by the writer when he examined, this spring (1906), the mulberry plantations of Fukushima and Gumma Prefectures, that had suffered severely by a late frost, April 30. Five earlier frosts<sup>1)</sup> had probably already done some injury. On arriving there on May 8 I noticed that nearly all the young leaf buds had turned brown and were dead, but in many cases at the base of each dead or half injured leaf bud, 4-6 young green panicles had started covered with small flower buds, producing a very singular appearance,<sup>2)</sup> so that a new formation of leaf buds but not of flower buds would be expected, especially as the bark was not the least injured by the frost. And further, what was still more remarkable, some very young buds which had not yet opened and therefore were not injured by the frost, showed, on being cut open, that they had

1). The dates, the maximum temperatures of air and soil, and the humidity of the air during the five frosts of April observed at Fukushima observatory are shown in the following table:

Date.	Minimum temperature of		Humidity of air at 2 p.m. (%)
	Air.	Soil.	
April 1 ... ..	-1.2° C	-6.0° C	28
" 11 ... ..	1.8° "	-4.6 "	48
" 12 ... ..	-2.7 "	-7.6 "	44
" 20 ... ..	-1.0 "	-5.6 "	28
" 21 ... ..	-0.2 "	-4.6 "	35
" 30 ... ..	-2.2 "	-9.0 "	22

2). Old mulberry trees, especially those which are not cut every year, show generally a tendency to form numerous flowers but there are commonly no flowers formed on those trees which are subjected to the annual cutting either from near the surface of the ground or from stumps 2-3 feet above the ground; those of a very poor growth are excepted. Some few varieties, however, show more or less tendency to form flowers even when cut every year.

turned into flower buds and young panicles were found between the young leaves. The photograph taken is reproduced on Plate XIV.

How is this phenomenon to be explained?

Some time ago O. Loew<sup>1)</sup> published some articles on the tendency of flowering, in which he pointed out that numerous facts render it very probable that a necessary condition for flower formation is a certain concentration of sugar in the plant juice. Further the removal of a part of the root, a deficiency of nitrogen, dryness of the soil and plenty of sunshine are favorable for flower formation, in that these conditions lead to an increase of sugar concentration. On the other hand, increased moisture of the soil, position in the shade and especially an increase of nitrogen favor much more the leaf formation than the flower formation, either by dilution of the sugar solution or by inducing transformation of sugar into asparagine and protein.

The conclusion at which O. Loew arrived was confirmed a short time afterwards by Hugo Fisher<sup>2)</sup> who mentioned however some more cases in which flower formation was induced by increase of the sugar concentration. He pointed out, e.g., that potatoe plants in a dry season with plenty of sun-shine produce more abundant flowers and less tubers than in moderately moist seasons. Further, cherry branches attacked by the fungus *Lixoxus* yield more leaves and less or no flowers compared with healthy branches of the same tree. Wires tied around the branch induce this branch in the following years to earlier and more abundant flowering. Then the sugar produced in the leaves can not be so abundantly transported to the trunk and roots and therefore reaches a higher concentration in the branches. *Iberis umbellata* just at the starting of flowering time placed behind blue or yellow solutions will produce more abundant flowers in the yellow light, on account of carbon assimilation being favored. Fisher mentions as a rule: nutrition by light and air (carbon assimilation) favors flower formation, while nutrition by soil and water favors leaf formation (protein formation, absorption of N, S, & P).

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1). Flora, 1905, p. 124 and 324 (Supplement).

2). Flora, 1905, p. 478. See also W. Benecke, Bot. Zeitg., 1906, April.

In the light of these facts, the above described phenomenon on the mulberry plants can be explained as follows :

In the 1st place, the development of the young leaves had drawn considerably on the stock of reserve protein in the neighboring parts of the bark and the remaining relatively larger amount of reserve starch yielded now a solution richer in sugar, and

In the 2nd place, the migration of the juice into the growing leaves, requiring a certain proportion of sugar, was stopped by their death and thus the concentration of the sugar in the sap was increased ; and

In the 3rd place, the dry weather before and after the frost favored more or less the flower formation by the concentration of the cell sap.

Travelling four weeks later in another prefecture (Ibaraki) I also noticed the damage to mulberry trees by the same frost (April 30) but in this case not only flowers developed from the base of the killed young leaves but in many cases the flowers were much more numerous in the *upper* part of the stem than in the *lower*, which is just the contrary of the normal phenomenon. The number of panicles<sup>1)</sup> observed on some of such stems are shown in the following table :

No. of branches from the top of stalk.	Number of panicles observed on the branches of six stalks.					
	A.	B.	C.	D.	E.	F.
No. 1	3	1	.....	2	.....	.....
" 2	3	2	.....	.....	.....	.....
" 3	4	.....	0	.....	5	.....
" 4	2	2	0	4	4	2
" 5	4	1 <sup>(2)</sup>	2	.....	2	4
" 6	4	.....	2	5	4	3
" 7	3	3	3	2	3	3
" 8	3	.....	3	.....	5	.....
" 9	1	3	.....	3	5	1 <sup>(2)</sup>
" 10	3	2	2	.....	2	2
" 11	4	0	3	.....	1	0

Dotted lines shows dead buds.

- 1). Nearly all panicles were stamined.
- 2). No leaves on these buds, only flowers.

No. of branches from the top of stalk.	Number of panicles observed on the branches of six stalks.					
	A.	B.	C.	D.	E.	F.
No. 12	3	0	.....	3	2	0
" 13	5	3	0	0	3	0
" 14	2	0	4	0	2	.....
" 15	.....	1	.....	.....	.....	2
" 16	3	1	1	.....	0	1
" 17	1	1	.....	2	0	0
" 18	.....	0	.....	0	.....	0
" 19	.....	0	.....	.....	.....	.....
" 20	1	1	1	.....	0	.....
" 21	0	0	.....	.....	.....	0
" 22	.....		0	2	.....	0
" 23	0		.....	.....	0	
" 24	.....		.....	.....	.....	
" 25	1		1	.....	.....	
" 26	2		0	0	.....	
" 27	0		.....	1	1	
" 28	0		0	.....	.....	
" 29	.....		.....	.....	0	
" 30	0		.....	.....	0	
" 31	1		.....	0	0	
" 32	0		0	0	0	
" 33	0		0	2	0	
" 34	1		1	0	0	
" 35			.....			
" 36			0			
" 37			0			
" 38						
" 39						

Dotted lines show dead buds.

Further, numerous buds were injured to such an extent that neither leaf nor flower developed from them, although at the base of the bud the bark proved still green and healthy. Furthermore in those cases in which the upper part of the stem was completely killed, it was observed that the branch development later on was most vigorous just below the dead

portion of the branch. Moreover in those cases in which the leaf-buds were merely injured by the frost without being killed, the number of panicles appearing at the base of these shoots was much larger than in those cases where less injury had been done, and finally no panicles at all appeared at the base of such branches which had developed after the frost from closed buds.—See Plate XIV and XV.

Finally it may be mentioned that I have tested for oxidizing enzymes in leaves entirely killed by frost and turned brown, and found oxydase and peroxydase to be absent, while catalase was plentiful. The water extract of frozen leaves was precipitated with alcohol, the precipitate dissolved in water and tested again for oxydases also with negative result. The behavior of oxydases towards freezing requires further observations. Further I have scraped off a considerable part of the living bark of such branches which had developed flowers from the base of killed leaf-buds and tested it in the usual way for cane sugar and glucose. It was thus observed that cane sugar was present in much larger quantities than glucose.

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**EXPLANATION OF PLATES.**

## PLATE XIV.

Three stems bearing 3-5 panicles on the base of every bud after frost.

## PLATE XV.

- Fig. (a) and (b). Half injured branches bearing 6-7 panicles on their bases.  
Fig. (c). A normal new branch coming out after frost and bearing no panicles.

## PLATE XVI.

- Fig. (A). A new branch bearing three panicles developing from the accessory bud after frost.  
Fig. (B). A stem on which all buds were severely damaged and developing no leaves until after four weeks, but producing many panicles from the base of the killed buds.
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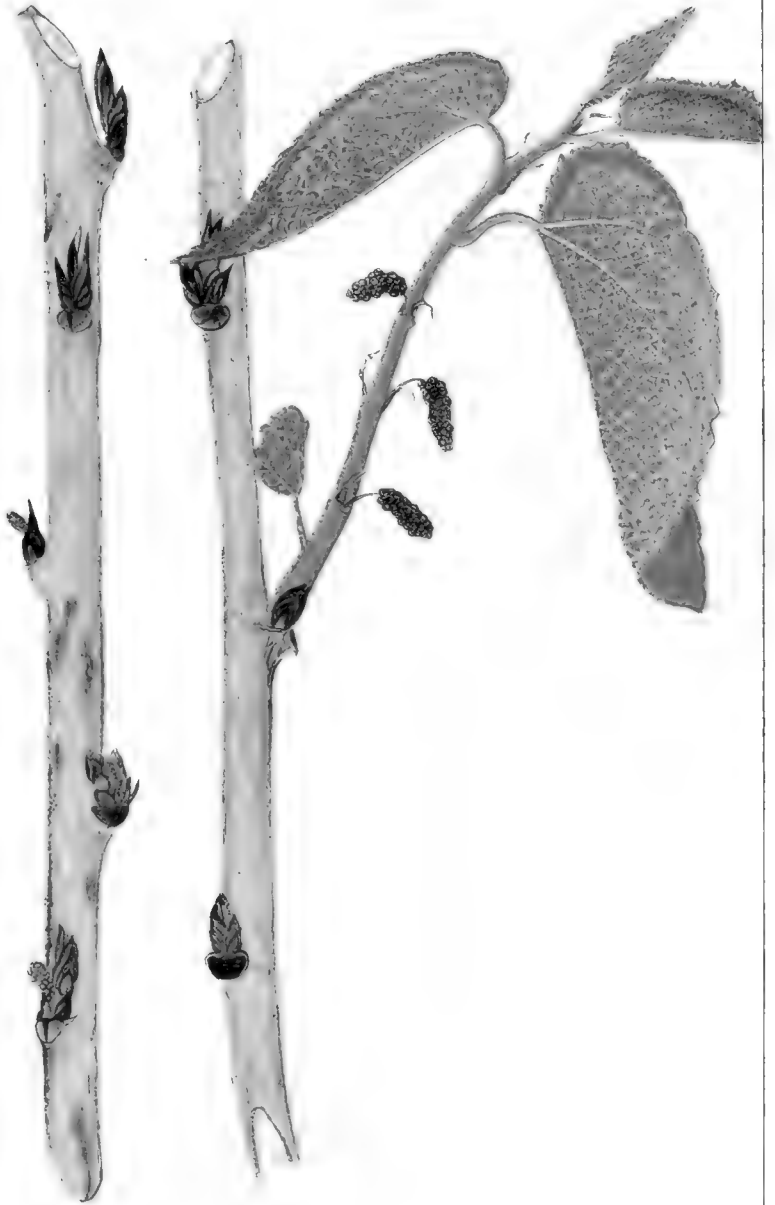












B.

A.



## On the Behavior of Nitrate in Paddy Soils.

BY

G. DAIKUHARA AND T. IMASEKI.

A great many manuring experiments carried out by different authors prove that under certain conditions nitrate nitrogen is superior to ammonia nitrogen, while under other conditions the reverse is true. It is to be regretted, however, that the different conditions, as nature of soil, its chemical composition and the character of the manure whether acidic or alkaline or neutral, have not always been stated, since this knowledge would have assisted much in recognising certain regularities.

For those tropical and subtropical countries, in which agricultural crops are raised in paddy soils or swamps, the question is also of vital importance, which of the two sources of nitrogen would be the more favorable. The conditions in the paddy soil for nitrification and denitrification are very different from those in the dry land soil. In the first place, the transformation of ammonia into nitrite by the nitroso-bacterium is very much depressed not only on account of less air penetrating into the soil, but also on account of much organic matter, which is by no means oxidized as easily as in dry land, and which according to Winogradsky, depresses the action of the nitrite-microbium; but also for the nitrate-microbium the conditions are very unfavorable, since its action is very much depressed by traces of ammonia. Loehnis<sup>1)</sup> however declared that only in the form of carbonate, ammonia is injurious for the nitrate-microbium not in the form of neutral salts. The paddy soil for rice culture in Japan has always been manured chiefly with excrements, fish manure, oil cakes, and frequently green manure; superphosphate was applied occasionally as a mere supplement to

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1). Chem. Ztg. Repertorium 1905, 1, 5.

those manures. These conditions being favorable for denitrification might lead to much loss, if nitrate were applied as a part of the nitrogen manure. Until recently however no experiments with plants cultivated in swamps have been made. It was Prof. M. Nagaoka<sup>1)</sup> who first carried out a number of careful experiments with plants cultivated by Japanese farmers in swamps as viz. rice, arrowhead (*Sagittaria sagittaeifolia*) and *Juncus effusus*. *Sagittaria* bulbs are used as food and *Juncus* is used for the manufacture of rugs. The Plants manured with nitrate remained pale in color and small in size. With rice the yield of the nitrate plants was only in one case a little above that of the control plants, in most cases, however, far below; in one case, where the soil received no lime and the ratio of 150 Kg N p. ha., the yield of the nitrate plants fell to about 2% of that of ammonia plants.

With *Juncus* the yield of the nitrate plants varied from 4.7-66% of the ammonia plants provided with equal doses of nitrogen. For *Sagittaria* the result was still more unfavorable. It is very remarkable that with *Juncus* the harvest of the nitrate plants diminished gradually with the increased applications of the nitrate.

Some experiments<sup>2)</sup> carried out by one of us (Daikuhara) with rice plants in sand culture showed that the availability of nitrate is 42% of that of ammonia nitrogen. The average ratio for the manurial value of ammonia nitrogen to that of nitrate nitrogen calculated from different results of experiments carried out in our central and branch Stations during the last few years is 100:47.

As to the reason why the paddy plants cannot utilize nitrate nitrogen so well as ammonia nitrogen, Nagaoka<sup>3)</sup> has proposed the two following factors:

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1). Bull. College of Agric., Imp. University, Tokyo, Vol. VI., No. 3.

2). This Bulletin Vol. I., No. 1.

3). Nagaoka has also ascribed the pale yellowish color of the nitrate plants to the physiological influence of accumulated nitrate, but according to our observations the pale yellowish color appears in the first period of growth, 2-3 weeks after the application of nitrate, and recovers afterwards. It is very probable, therefore, due to the poisonous action of nitrite formed by the reducing action of certain bacteria.



1. Paddy plants do not accumulate a sufficient quantity of sugar in the leaves to convert all of the nitric acid absorbed into protein.

2. In paddy soils, denitrification and also formation of poisonous nitrites may take place.

As to the first we have instituted some tests. It might be assumed that an injurious accumulation of nitrate may take place in the leaves of the rice plants manured with nitrate but as to this there is no positive proof yet. But the result of our analysis shows practically no difference not only between the leaves of paddy and dry land rice, but also between those of the paddy rice applied with ammonium sulphate and sodium nitrate as shown in the following tables :

A. Sugar content in the leaves of the paddy and dry land rice.

Kind of rice plant.	Name of varieties.	Period of Growth.	Glucose %	Cane sugar %	Total sugar %
Paddy rice	Shin-shu ...	Before flowering	1.19	0.48	1.67
		Milky ripening	2.04	0.74	2.78
		Yellow ripening	1.94	0.24	2.18
	Suga-ippon.	Young leaves	0.89	0.48	1.37
		Before flowering	1.21	0.64	1.85
		Milky ripening	2.48	1.15	3.63
Yellow ripening		2.47	0.55	3.02	
Dry land rice	Oiran ...	Before flowering	1.19	0.56	1.75
		Milky ripening	2.02	0.85	2.87
		Yellow ripening	2.16	0.56	2.72
	Kiushu ...	Young leaves	0.89	0.52	1.41
		Before flowering	1.29	0.69	1.98
		Milky ripening	2.00	1.10	3.10
Yellow ripening		2.59	0.46	3.05	

## B. Sugar content in the leaves of paddy rice with different manures.

Kind of Manures.	Period of Growth.	Glucose %	Cane sugar %	Total sugar %
Ammonium sulphate	Young leaves	0.99	0.33	1.32
	Before flowering	1.60	0.56	2.16
	Milky ripening	1.56	0.66	2.22
Sodium Nitrate	Young leaves	0.87	0.47	1.34
	Before flowering	1.35	0.50	1.85
	Milky ripening	1.36	0.75	2.11

Thus we see that the first assumption by Nagaoka was not justified.

Some tests were made by Nagaoka with regard to the second cause, rendering however further observations desirable and we have therefore further studied the behavior of swamp plants towards nitrate, being certainly of considerable theoretical and practical importance.

With the denitrifying organisms in a wide sense the following groups may be distinguished after Jensen<sup>1)</sup>:

1. Reduktion von Nitraten zu Nitriten und Ammoniak (Salpeterreduktion).
2. Reduktion von Nitraten zu Nitriten und niedrigeren, gasförmigen Stickstoff-Sauerstoffverbindungen ( $N_2O$  und  $NO$ ).
3. Reduktion von Nitraten und Nitriten unter Abspaltung elementaren Stickstoffes (Denitrifikation im engeren und eigentlichen Sinne).
4. Umbildung des Salpeterstickstoffes in organische Verbindungen (Salpeterassimilation).
5. Freiwerden von Stickstoff bei der Fäulnis organischer Stickstoffverbindungen."

Denitrification will proceed much more energetically in moist land than in dry land and also nitrates will be reduced to nitrites more

1). Lafer, Handb. d. Techn. mycologie Band III, S. 182.

energetically by peculiar bacteria of the paddy soil, and these nitrites may persist for a time before they are further reduced to ammonia. Certain bacteria reduce nitrates very quickly to ammonia so that the intermediary step, the formation of nitrites, can not be recognized. Certain other bacteria, however, produce considerable quantities of nitrites from nitrates. Nitrites however show a strong poisonous character, since they act very powerfully on the amido-groups and hence will also attack the amido-groups of proteins and thus kill the living protoplasm.

In order to decide whether denitrification takes place extensively in paddy soil the following experiments were made :

#### LABORATORY EXPERIMENT. I.<sup>1)</sup>

One hundred g of soil were placed in an Erlenmeyer's flask of 300 cc. capacity and added 150 cc. of a solution containing 2 g of sodium nitrate and 0,2 g of  $K_2HPO_4$  which liquid kept the soil covered in a thin layer. A humy soil from our experimental field, a sandy loam soil from Kinai Branch Station and a heavy clayey soil from Kaga Province served for this experiment. The experiment was started on March 23, 1905; the flasks were shaken every day and tested from time to time for nitrite by the reaction of Griess. The room temperature during this experiment was 16-26°C. After 24 hours a very decisive reaction for nitrite was already observed with the humus soil, much less than in the sandy soil, and only a trace was found in the clayey soil. After 5 resp. 6 days, the maximum point of formation of nitrite (0,003 resp. 0,002%  $KNO_2$ )<sup>2)</sup> was attained in the humy and the sandy soil, whereupon the nitrite decreased, disappearing after 3 resp. 4 weeks, much nitrate still remaining in the solution. In the clayey soil, however, the reduction of nitrate was very slow and the maximum point was reached (0,01% nitrite) after 4 weeks; a little nitrite was still present even after 5 months. From the start of the experiment ammonia was occasionally tested for and reactions obtained in all of the

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1). Laboratory experiment I, II, III, IV, V and VI (d) were carried out by G. Daikuhara, and Laboratory expt. VI (a), (b) and (c) by T. Imaseki.

2). By colorimetric determination.

flasks, especially with the sandy soil, somewhat less so with the clayey soil and still weaker in the humus soil. With the humus and sandy soils a little sodium acetate was added to accelerate the bacterial action, after the nitrite reaction had disappeared. Thus again a gradual increase of the nitrite was observed and finally it reached a concentration of 0,1% resp. 0,05% nitrite 12 days after that addition, much foam being developed. No ammonia was observed in this case.

Further to ascertain whether the reduction of nitrate was due to bacteria, the mixture of soil and the nitrate solution mentioned above, was sterilized with steam, with chloroform and with mercuric chloride. Occasional testing for nitrite showed the absence of nitrite even after several weeks. This proves clearly that the reduction of nitrate in soils in the paddy state certainly is due to the action of denitrifying organisms.

#### LABORATORY EXPERIMENT. II.

Since in Japan much organic manure is commonly used in the paddy field, it is of vital importance to observe the influence of organic matter upon the reduction of nitrate in the paddy state. 150 cc. of the following nitrate solution was mixed with 100 g of air dry soil and kept at a temperature of 30-32°C. It was found that all the nitrate was reduced entirely after 48 hours.

Na-acetate (or glycerine) ... ..	0.5 %
NaNO <sub>3</sub> ... ..	0.2 %
K <sub>2</sub> HPO <sub>4</sub> ... ..	0.2 %
MgSO <sub>4</sub> +7H <sub>2</sub> O ... ..	0.02%

On April 15, 1905, 100 g of the three different soils above mentioned were mixed with the same nitrate solution containing glycerine and kept at room temperature (13-26°C). The occasional tests for nitrite and ammonia gave the following results:

(a). Test for nitrite.<sup>1)</sup>

From the start.	Humy clay soil.	Sandy loam soil.	Clay soil.
After 3 days	0.0013% KNO <sub>2</sub>	0.004% KNO <sub>2</sub>	0.002% KNO <sub>2</sub>
„ 4 „	0.0010% „	0.005% „	0.003% „
„ 6 „	0.0033% „	0.005% „	0.007% „
„ 9 „	trace	trace	0.0008% „
„ 12 „	o	o	trace

## (b). Test for ammonia.

From the start.	Humy clay soil.	Sandy loam soil.	Clay soil.
After 3 days	little	moderate	moderate.
„ 4 „	„	„	„
„ 6 „	„	„	„
„ 9 „	„	„	„
„ 12 „	trace	trace	little

The above result shows that by the presence of a certain amount of organic matter the reduction of nitrate in the paddy soil is much accelerated and all the nitrate added (0.2%) reduced entirely after 9-12 days even at room temperature in spring and after 2 days when kept at 30-32°C.

## LABORATORY EXPERIMENT. III.

Former experiments carried out by various investigators show that fresh stable manure favors denitrification more than a well rotten one, but in regard to fresh and rotten oil cakes no special observations seem to have been made, therefore we have made the following experiment :

(a). On Aug. 14, 1905, 100 g of soil from our Station at Nishigahara 2 g of rape cake (1) and 5 cc. of glycerine (2) and 150 cc. of the nitrate

1). The amount of nitrite was also here approximately determined colorimetrically by Griess test. A standard solution of pure KNO<sub>2</sub> served for the comparison.

solution of the following composition and kept at room temperature (20–32°C) with occasional testing for nitrite and nitrate :

NaNO <sub>3</sub> ... .. .	2.00 g	} dissolved in 150 cc. H <sub>2</sub> O.
K <sub>2</sub> HPO <sub>4</sub> ... .. .	0.20 g	
MgSO <sub>4</sub> +7H <sub>2</sub> O ... .. .	0.02 g	

After 24 hours a stronger nitrite reaction was observed in (1) than in (2) (0.05% resp. 0.005% nitrite as KNO<sub>2</sub>). The maximum amount of nitrite was attained after 3 days with (1) and after 5 days with (2) but after 4 resp. 7 weeks all the nitrate was reduced. Thus we see that fresh rape cake favors denitrification much more than glycerine.

(b). Some rape cake and soy bean cake were left to putrefy in a warm place with a moderate supply of water and after 2 months rotting, samples were dried and finely pulverized. Two g of each, fresh cakes and the same amount of dry matter of the rotten cakes were mixed respectively with 100 g of air dry soil and 150 cc. of the following nitrate solution, and kept at 25°C.

NaNO <sub>3</sub> ... .. .	1.75 g	} dissolved in 150 cc. of H <sub>2</sub> O.
K <sub>2</sub> HPO <sub>4</sub> ... .. .	0.50 g	
MgSO <sub>4</sub> +7H <sub>2</sub> O ... .. .	0.05 g	

The tests showed that with fresh rape cake all the nitrate was reduced after 2 weeks, but with rotten cake much nitrate was still present even after 10 weeks. With soy bean cake which is poorer in carbohydrates and richer in protein the difference was much smaller and the nitrate was reduced entirely in the case of fresh and rotten cake after 10 and 12 days respectively.

Thus we see that the fresh rape cakes favor denitrification much more than the rotten.

#### LABORATORY EXPERIMENT. IV.

To see the effect of inoculation of denitrifying organisms, pure cultured, into the soil in the paddy state, the following 3 organisms were selected :

- a). Bact. denitrificans I. }<sub>1)</sub>  
 b). „ „ II. }  
 c). „ nitrovorum.

One hundred g of soil from our Experiment Station were kept in an Erlenmeyer's flask of ca. 300 cc. capacity with 100 cc. of nitrate solution as in Expt. III, (a). After repeated sterilization the denitrifying organisms were inoculated on Aug. 16, 1905, and kept at room temperature. Of the supernatant solutions small doses were withdrawn from time to time with a sterilized pipette, and tested for nitrate, nitrite and ammonia with the following results:

(a). Bact. denitrificans I. Much nitrite was found after 24 hours and after 6 days the amount of nitrite reached the maximum (0.125%  $\text{KNO}_2$ ). But even after 2 months later both nitrate and nitrite were still present.

(b). Bact. denitrificans II. The nitrite reaction was observed after 2 days from the start and after 9 days this reaction showed the maximum. All the nitrate and nitrite were reduced after 13 days from the start.

(c). Bact. nitrovorum. Nitrite was observed also after two days, the maximum point of the nitrite reaction after 6 days, and the disappearance of both nitrate and nitrite after 16 days from the start.

A moderate ammonia reaction was obtained in each mixture after 3 days, (a) yielded much, (b) and (c) a weak ammoniacal reaction after 5-10 days, and still a moderate reaction after 2 weeks.

Further with the flask (a) much pasty film was noticed on the surface of the soil, but with flasks (b) and (c) this was not the case; the liquids became gradually turbid and of a light reddish-brown color.

#### LABORATORY EXPERIMENT. V.

To observe the influence of starch, compost, straw and rape cake upon the reduction of nitrate in paddy soil and to determine the loss of nitrogen by denitrification the following experiment was made.

On Sept. 18, 1905, 28 Erlenmeyer's flasks of ca. 300 cc. capacity were

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1). These two organisms were isolated from the soil in the field of this Station by S. Machida. Burri and Stutzer were the first to isolate denitrifying bacteria in pure culture.

filled with 200 g of humy soil from Nishigahara containing 30.53%  $H_2O$  and mixed with the following salts,<sup>1)</sup> dissolved in 250 cc.  $H_2O$ , and organic manures.<sup>1)</sup> As general nutrients 0,5 g di-potassium-phosphate and 0,05 g magnesium sulphate were added to each flask and kept at room temperature (15-26°C).

I.	Ammonium sulphate <sup>2)</sup> ... ..	1.25 g.
II.	Sodium nitrate... ..	" "
III.	Ammonium nitrate ... ..	" "
IV.	{ Sodium nitrate ... ..	" "
	{ Starch ... ..	2.00 "
V.	{ Sodium nitrate ... ..	1.25 "
	{ Compost well rotten (a) sterilized ... ..	6.00 "
VI.	{ Sodium nitrate ... ..	1.25 "
	{ Compost well rotten (b) not sterilized ... ..	6.00 "
VII.	{ Sodium nitrate ... ..	1.25 "
	{ Rape cake ... ..	2.00 "
VIII.	{ Sodium nitrate ... ..	1.25 "
	{ Straw in powder ... ..	6.00 "
IX.	Starch ... ..	2.00 "
X.	Compost well rotten (a) sterilized... ..	6.00 "
XI.	Compost well rotten (b) sterilized... ..	6.00 "
XII.	Rape cake ... ..	2.00 "
XIII.	Straw in powder ... ..	6.00 "
XIV.	Control ... ..	—

The experiment was carried out in duplicate. While one series served for occasional testing the other served for the final determination. It was observed that flasks containing starch, rape cake and straw showed the strongest reaction for nitrate, and with the starch flask after 10 days from start,

1). Nitrogenous manures subjected to this experiment contained the following percentage of N:

a.	Ammonium sulphate ... ..	2.5 % N
b.	Ammonium nitrate ... ..	34.80 "
c.	Sodium nitrate... ..	15.55 "
d.	Compost well rotten ... ..	8.7 "
e.	Compost well rotten (b) ... ..	1.43 "
f.	Straw ... ..	8.57 "

2). One g of precipitated magnesium carbonate was added to neutralize the acidity of sulfuric acid



with the rape cake flask after two weeks and with the straw flask after four weeks, all the nitrate and nitrite were reduced. In the other flasks, however, to which the nitrate was added much nitrate was still present after 6 weeks and in the ammonium sulphate flask also strong reactions for nitrate and nitrite were noticed after three weeks. With Compost flasks (a) and (b) moderately strong nitrite reactions were observed after 2-3 days from the start but the reaction decreased gradually.

The flasks for the final determinations were kept for 45 days with frequent shaking until the nitrite reaction had entirely disappeared. 100 cc. of supernatant clear solution were withdrawn from each flask to determine the soluble nitrogenous compounds, and the remainder in the flask was evaporated to dryness after adding a little sulphuric acid. The total nitrogen, nitric and ammoniacal nitrogen were determined as usual with the following results :

No. of Flasks.	Total air dry soil.	In 100 parts of air dry soil.			In 100 part of the supernatant solution		Total amount of		
		Total N.	Ammonia N.	Nitric N.	Ammonia N.	Nitric N.	Total N. g	Ammonia N. g	Nitric N. g
I.	144.4	0.456	0.098	0.005	0.043	0.004	0.705	0.184	0.011
II.	147.9	0.403	0.034	0.082	0.003	0.072	0.671	0.053	0.193
III.	147.0	0.495	0.053	0.094	0.043	0.072	0.843	0.120	0.210
IV.	142.3	0.311	0.015	0	0.004	0	0.447	0.025	0
V.	153.3	0.443	0.010	0.075	0.003	0.068	0.750	0.017	0.183
VI.	151.4	0.439	0.005	0.071	0.002	0.068	0.735	0.010	0.175
VII.	147.6	0.381	0.025	trace	0.006	trace	0.568	0.043	0
VIII.	152.9	0.348	0.005	0	0.001	0	0.533	0.009	0
IX.	143.0	0.307	0.020	0	0.001	0	0.440	0.030	0
X.	148.5	0.401	0.025	0	0.003	0	0.598	0.038	0
XI.	152.0	0.395	0.007	trace	0.003	trace	0.603	0.012	0
XII.	147.5	0.377	0.015	0	0.005	0	0.561	0.026	0
XIII.	153.5	0.340	0.004	0	0.002	0	0.524	0.007	0
XIV.	145.7	0.322	0.008	0.024	0.001	0.008	0.478	0.013	0.043

From the above figures the loss of nitrogen by the reduction of nitrate was calculated with the result shown in the following tables :

No. of flasks.	Kind of N-manures applied.	Remaining amount of soluble N applied.	Amount of soluble N applied.	percentage of soluble N remaining.	Loss of soluble N applied.
I.	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	0.227 g.	0.256	88.7 %	11.3 %
II.	NaNO <sub>3</sub>	0.193 "	0.194	99.5 "	0.5 "
III.	NH <sub>4</sub> NO <sub>3</sub>	0.365 "	0.435	83.9 "	16.1 "
IV.	NaNO <sub>3</sub> + starch	0.007 "	0.194	3.6 "	96.4 "
V.	" + compost a)	0.152 "	0.194	78.3 "	21.7 "
VI.	" + " b)	0.135 "	0.194	68.6 "	31.4 "
VII.	NaNO <sub>3</sub> + rape cake	0.007 "	0.194	3.6 "	96.4 "
VIII.	" + straw	0.009 "	0.194	4.6 "	95.4 "

This result confirms the observations made by occasional testing as above stated and clearly shows that the starch, rape cake and straw very much favor denitrification in the paddy soil, while well rotten compost especially when sterilized has far less influence upon denitrification. But little loss of nitrogen took place in flask II to which nitrate alone was applied, perhaps by the accidental absence of the denitrifying microbes proper.

#### LABORATORY EXPERIMENT VI.

To observe whether nitrate formation and denitrification<sup>1)</sup> take place in the dry land state, the following experiments were carried out.

##### A. Dry land top soil.

One hundred g of the following three samples of soil were placed in Erlenmeyer's flasks of ca. 300 cc. capacity with 2 g of sodium nitrate in solution and kept in a moderately dry condition, and in control flasks the same amount of distilled water was applied :

1). Nitrite formation is frequently the first step of denitrification with loss of nitrogen. In certain cases however the nitrite may be completely reduced to ammonia.

- 1). Humy soil of a field, from Nishigahara.
- 2). Clay soil from Kaga province.
- 3). Alluvial sandy loam soil from Arakawa, near Tokyo.

The experiment was begun April 11, 1905, and lasted 50 days, every day a portion of the contents of each flask was withdrawn to test for nitrite. The room temperature was 17-25°C. During 12 days from the start slight reaction for nitrite was observed in the soil (1) and (2) and then the reaction disappeared. In the soil (3) no trace of nitrite was found through the whole period. Thus we see that little or no nitrite formation takes place in the top soil of the dry land state, especially in the sandy soil and when nitrate alone was applied.

#### B. Top and Sub-soil in dry land state.

The same soils as in Experiment (A) just described served also for this experiment. They yielded the following chemical and physical data :

	(1) Humy soil.	(2) Clay soil.	(3) Sandy loam soil.
Hygroscopic water ... ..	12.53	1.81	2.90
Loss by ignition... ..	16.23	4.09	5.11
Nitrogen ... ..	0.35	0.22	0.19
Weight of $\left\{ \begin{array}{l} \text{in loose state ...} \\ \text{in compact state.} \end{array} \right.$ 100 cc.	$\left\{ \begin{array}{l} 60.40 \\ 105.55 \end{array} \right.$	$\left\{ \begin{array}{l} 93.50 \\ 146.50 \end{array} \right.$	$\left\{ \begin{array}{l} 98.25 \\ 150.15 \end{array} \right.$
Absorptive $\left\{ \begin{array}{l} \text{in loose state ..} \\ \text{in compact state.} \end{array} \right.$ power for H <sub>2</sub> O	$\left\{ \begin{array}{l} 106.67 \\ 70.25 \end{array} \right.$	$\left\{ \begin{array}{l} 49.77 \\ 31.81 \end{array} \right.$	$\left\{ \begin{array}{l} 48.62 \\ 31.28 \end{array} \right.$

450, 550 and 600 g of these soils resp. were mixed with 4 g of sodium nitrate in a moderate concentration and put in glass cylinders of 3.6 cm. diametre and 36 cm. height open at both ends, the upper half of the soil in a loose condition and the lower half in a compact condition, the lower end of the cylinder being closed with linen smeared with melted paraffin. Besides, the cylinders were covered with black paper, sun-light being allowed to reach only the surface of the soils.

The experiment was begun April 12, 1905, and every 2 days in the first period and every 5 days in the later, a portion was withdrawn from the upper and lower layers and tested for nitrate, nitrite and ammonia with the following result :

(1). In the humy soil to which sodium nitrate was added a little nitrite was observed after 2 weeks, increasing a little afterwards, and the reaction was always stronger in the sub-soil than in the top-soil. The reaction for ammonia was observed after one week and was always stronger in the top-soil.

In the control case, however, no nitrite was found through the whole period ; after one month a trace of ammonia and after 50 days a trace of nitrate was observed.

(2). In the clay soil to which sodium nitrate was added, a little nitrite was observed after 2 days from the start, the reaction in the sub-soil increasing gradually, reaching the maximum after 2 weeks and remaining the same through the whole period, while in the top-soil no further increase was noticed. Much ammonia was found after two days from the start, the reaction of which was always stronger in the top-soil, just as with the humy soil (1). In the control case, neither nitrate nor nitrite was formed through the whole period, but a trace of ammonia was found after one month, a little more in the top-soil than in the sub-soil.

(3). In the sandy loam to which sodium nitrate was added, a trace of nitrite was observed in the sub-soil after 3 days from start, and the reaction increasing gradually, reached the maximum after 2 weeks, while in the top-soil only a slight reaction for nitrite was observed after 2 weeks. With regard to ammonia, only a trace of it was found after one week which remained constant through the whole period. In the control case, neither nitrate, nor nitrite was found through the whole period and not even a trace of ammonia was found.

The second experiment was carried out with the same soil and cylinders for a longer period viz. five months (June 26—October 28, 1905), the result of which exactly coincided with that of the former experiment above stated. Thus we see that denitrification takes place more or less in the

sub-soil in dry land state, while in the top-soil when kept in a loose condition almost no reduction of nitrate occurs if nitrate alone is applied to the field.

(C). The dry land state with application of some organic substance.

In order to determine the influence of the presence of some organic matter in the soil in dry land state upon denitrification, the following experiment was made with the three soils mentioned below :

- 1). Humy top-soil from a field of Nishigahara.
- 2). Clayey sub-soil „ „ „
- 3). Alluvial sand soil from Arakawa.

The cylinders of the diametre of 4 cm. and of the height of 55 cm. open at both ends, were filled with each soil in the air dry state, upper layer of 25 cm. deep in loose condition and lower layer of 30 cm. deep in compact condition. The soils of the first series were mixed with a solution of sodium nitrate and those for the second series with the same nitrate solution and starch, the ratio of both the nitrate and starch to the soil being 1 : 100. The soils were kept moderately moist and the lower open end of the cylinder was covered with filter paper and linnen and kept air tight with melted paraffin. The sides of the cylinders were covered with black paper.

The experiment was begun Oct. 5, 1905, and was finished Nov. 24, during the first period of which every two days, and later on every 10 days, a portion of the upper and lower layers of the soil was taken out by boring and tested for nitrate, nitrite and ammonia with the following result :

(1). In the humy top-soil to which both the nitrate and starch were applied, much nitrate was present in the upper layer during the whole period, while in the lower layer the nitrate decreased gradually and after 20 days only a trace of it was observed. The soil to which nitrate alone was applied showed a strong reaction for nitrate in both upper and lower layers until the end of the experiment. As to nitrite a trace of it was found in the lower layer during the first period in all cylinders which received nitrate and the reaction disappeared after 12 days in the cylinder to which the nitrate solution alone was applied, while in the cylinder to which both nitrate and

starch were applied the reaction became evident gradually, reaching the maximum after 10 days and then it gradually diminished to a trace after 20 days from start.

(2). In the clayey sub-soil a trace of nitrite was observed in the lower layer of all cylinders except that of the control case, and no further increase of nitrite was noticed in the cylinder to which nitrate alone was applied, while in the cylinder with nitrate and starch the reaction increased gradually reaching the maximum after three weeks from the start and afterwards decreasing gradually but showing the reaction until the end of the experiment.

(3). In the sandy soil with nitrate and starch the nitrate decreased remarkably after 10 days from the start in both upper and lower layers of the soil and after 20 days all the nitrate was reduced, while in the soil with nitrate alone, the nitrate reaction remained intense through the whole period. With nitrite there was no reaction in the control soil and the soil with nitrate alone, while in the soil with nitrate and starch a trace in the upper layer and much of it in the lower layer of soil were observed after 2-3 days from the start, reaching the maximum after 10 days and then decreasing gradually again.

The above results show that in the soil of the dry land state there is hardly any nitrite formation if the nitrate alone is applied. When, however, some organic matter is applied together with the nitrate some reduction will take place, especially in the sub-soil, where the access of air is insufficient, even all the nitrate here will eventually be reduced.

(D). Comparison of the effect of some organic manures upon the formation of nitrite and denitrification.

In order further to compare the effects of different organic matters, such as starch, rape cake, compost and straw, upon the degree of denitrification in the dry state of land, the following experiment was carried out :

Ten glass flasks of ca. 1 litre capacity with greased stoppers were filled with 700 g of fine humy soil from Nishigahara containing 19.15% of hygroscopic water. 150 cc. of a solution containing 3.5 g of  $\text{NaNO}_3$ , 2 g of

$K_2HPO_4$  and 0.3  $MgSO_4$  were added to the flasks No. I-V, and the same amount of a solution containing only 2 g  $K_2HPO_4$  and 0.3 g  $MgSO_4$  without nitrate to the flasks No. VI-X, after mixing the soil thoroughly with the organic matters<sup>1)</sup> mentioned :

I.	$NaNO_3$ ... ..	3.5 g.
II.	{ $NaNCO_3$ ... ..	3.5 "
	{ Starch ... ..	5.0 "
III.	{ $NaNO_3$ ... ..	3.5 "
	{ Ccmpost, well rotten ... ..	21.0 "
IV.	{ $NaNCO_3$ ... ..	3.5 "
	{ Rape cake ... ..	5.0 "
V.	{ $NaNO_3$ ... ..	3.5 "
	{ Straw ... ..	10.0 "
VI.	Starch (Control (a)) ... ..	5.0 "
VII.	Compost well rotten (Control (b))... ..	21.0 "
VIII.	Rape cake (Control (c)) ... ..	5.0 "
IX.	Straw (Control (d))... ..	10.0 "
X.	..... (Control (e)) ... ..	—

The experiment was begun Sept. 5, 1905, and every 10 days a certain portion was withdrawn from each vessel, the same amount of water added and tested for nitrite in the filtrate. After 10 days much nitrite was observed in the flasks II and IV, the amount of which as potassium salt approximately determined 0.35% resp. 0.088%  $KNO_2$ . In flask III only a little nitrite and in all other flasks (except II and IV) only a trace or none of it was observed. After one month in all the flasks only traces of nitrite could be found.

The result shows that in top-soil of "dry" land only certain organic matters, such as starch or rape cake, favor nitrite formation to some extent, but well rotten compost and straw do not.<sup>2)</sup>

Increase of moisture will lead to an increase of nitrite and loss of nitrogen ; water was added after 33 days from the start at the ratio of 10 cc.

1). The contents of N in the nitrate and organic manures are the same as in Lab. Expt. V.

2). Stoklasa (Z. Landw. Vers. Wes. in Oesterreich, 1906, p. 844.) observed in Austrian soils serving for culture of sugar beets also denitrification did not take place to such an extent that it could be proved analytically.

H<sub>2</sub>O to every 100 g original soil, thus keeping the soil in just a moderately moist condition. After 10 days nitrate reactions were obtained in the flasks II, IV and V. After two months from start the soil was dried after acidulating with a little H<sub>2</sub>SO<sub>4</sub> and the total N, ammonia N and nitric N determined.

No. of flasks.	Kind of Manures.	In 100 pts dry soil.			N in total dry soil (g).		
		Total N.	Amm. N.	Nitric N.	Total N.	Amm. N.	Nitr. N.
I.	NaNO <sub>3</sub>	0.452	0.005	0.102	2.558	0.028	0.577
II.	NaNO <sub>3</sub> + starch	0.397	0.005	0.018	2.145	0.028	0.102
III.	NaNO <sub>3</sub> + compost	0.456	0.022	0.100	2.581	0.125	0.566
IV.	NaNO <sub>3</sub> + rape cake	0.477	0.038	0.082	2.683	0.215	0.464
V.	NaNO <sub>3</sub> + straw	0.432	0.016	0.082	2.445	0.091	0.464
VI.	starch	0.372	trace	0.006	2.105	—	0.034
VII.	compost	0.382	0.005	0.011	2.162	0.028	0.062
VIII.	rape cake	0.401	0.016	0.027	2.269	0.091	0.153
IX.	straw	0.354	0.011	0.027	2.003	0.062	0.153
X.	.....	0.368	trace	0.004	2.083	—	0.023



From these figures the loss of nitrogen was calculated.

No. of flasks.	Kind of manures.	Soluble N applied (g).	Loss of N by denitrification.	
			g	%
I.	NaNO <sub>3</sub>	0.544	0.069	12.7
II.	NaNO <sub>3</sub> + starch	0.544	0.504	92.6
III.	NaNO <sub>3</sub> + compost	0.544	0.125	23.0
IV.	NaNO <sub>3</sub> + rape cake	0.544	0.130	23.9
V.	NaNO <sub>3</sub> + Straw	0.544	0.102	18.5

These results show that when common dry land top-soil becomes sufficiently moist, as by continuous rains, the presence of an easily putrefying organic matter favors denitrification to a considerable degree.<sup>1)</sup>

### VEGETATION EXPERIMENT I.<sup>2)</sup>

In order to ascertain the effect of the formation of nitrite and denitrification upon vegetation, the following experiments were made: Six zinc pots of ca. 30 cm. in diameter were filled with 15 Kg of humy soil from Nishigahara and six with alluvial soil from Arakawa. The following manures were applied per pot (in duplicate):

(A).	{	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ... .. .	5.0 g	
		Na <sub>2</sub> HPO <sub>4</sub> ... .. .	5.0 "	
		K <sub>2</sub> SO <sub>4</sub> ... .. .	5.0 "	
(B).	{	NaNO <sub>3</sub> ... .. .	6.7 "	(N in equivalent to (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> )
		Na <sub>2</sub> HPO <sub>4</sub> ... .. .	5.0 "	
		K <sub>2</sub> SO <sub>4</sub> ... .. .	5.0 "	

1). A considerable degree of denitrification was observed by Hugo Fisher after moderately liming the soil, but the amount of moisture was not stated.  
 2). All vegetation experiments were carried out by G. Daikuhara.

(C).	{	NaNO <sub>3</sub> ...	...	...	...	6.7 g.
		Na <sub>2</sub> HPO <sub>4</sub>	...	...	...	5.7 "
		Glycerine	...	...	...	100 cc.

Five young paddy rice plants (*var. Sakitori*) equal in size were transplanted in each pot on July 5, 1905, and kept in paddy state. The plants in pot (A) was normal while those in pot (B) and (C), showed a yellowish green color in the first period of growth and much foam gathered on the surface of the soil especially in pot (C). After two weeks, however, the plants in pot (B) and (C) again acquired a green color but not the deep green as observed in pot (A).

The following table shows the result of observations on July 25 and on Sept. 5, 1905 :

## A. Soil from Nishigahara.

Kind of Manures.	Length of plants (cm).				Number of stalks.			
	July 25		Sept. 5		July 25		Sept. 5	
	p. pot.	Average.	p. pot.	Average.	p. pot.	Average.	p. pot.	Average.
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	74.3	73.2	109.1	106.8	27	30	61	60
	72.1		104.5		33		58	
NaNO <sub>3</sub>	61.2	61.7	107.5	104.5	22	22	45	46
	62.1		101.5		22		46	
NaNO <sub>3</sub> + Glycerine	56.1	56.1	89.4	91.8	17	17	20	20
	56.1		94.2		17		20	

## B. Soil from Arakawa.

Kind of Manures.	Length of plants (cm).				Number of stalks.			
	July 25		Sept. 5		July 25		Sept. 5	
	p. pot.	Average.	p. pot.	Average.	p. pot.	Average.	p. pot.	Average.
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	75.8	72.5	104.9	103.5	26	29	54	55
	69.1		102.1		32		55	
NaNO <sub>3</sub>	60.6	60.0	108.4	104.7	19	17	34	33
	59.2		100.9		15		31	
NaNO <sub>3</sub> + Glycerine	51.5	50.0	88.0	86.5	12	14	13	15
	48.5		85.0		15		17	

A photograph taken Sept. 2, 1905, and reproduced on Plate XVII shows clearly the differences in development. The plants were cut Oct. 25, 1905, and weighed in the air dry state with the following result :

## A. Soil from Nishigahara.

Kind of Manures.	Weight of Grains (g.)		Weight of Straw (g.)		Total Yield (g.)		Ratio of Total Yield.
	p. pot.	Average.	p. pot.	Average.	p. pot.	Average.	
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	67.13	61.31	129.38	128.44	196.50	189.75	100
	55.50		127.50		183.00		
NaNO <sub>3</sub>	57.75	56.81	85.50	87.94	143.25	144.75	76
	55.88		90.38		146.25		
NaNO <sub>3</sub> + Glycerine	25.50	26.25	37.50	37.88	63.00	64.13	34
	27.00		38.25		65.25		

## B. Soil from Arakawa.

Kind of Manures.	Weight of Grains (g).		Weight of Straw (g).		Total Yield (g).		Ratio of Total Yield.
	p. pot.	Average.	p. pot.	Average.	p. pot.	Average.	
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	64.13	66.75	114.00	113.25	178.13	180.00	100
	69.37		112.50		181.88		
NaNO <sub>2</sub>	38.63	36.19	70.88	66.94	109.50	103.13	57
	33.75		63.00		96.75		
NaNO <sub>3</sub> + Glycerine	18.75	17.81	22.13	22.13	40.88	39.94	22
	16.88		22.13		39.00		

This result coincides exactly with that of the laboratory experiments stated above and shows that glycerine favors denitrification in paddy soil very much. The yellowish color of plants during the first period of growth is most probably due to the poisonous action of nitrite formed by the reduction of nitrate.

## VEGETATION EXPERIMENT II.

36 zinc pots of ca. 25 cm. in diameter were filled with 11 Kg of humy soil from Nishigahara and the following manures applied, 3 pots serving for each trial.

No. of pots.	Kind of Manures.	Amount of Manures applied p. pot.
I.	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ... ..	5.0 g.
II.	NaNO <sub>3</sub> .. .. .	6.6 ..
III.	{ (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ... .. .	2.5 ..
	{ NaNO <sub>3</sub> ... .. .	3.3 ..
IV.	{ NaNO <sub>3</sub> ... .. .	6.6 ..
	{ starch. ... .. .	1.5 ..

No of pots.	Kind of Manures.	Amount of Manures applied p. pot.
V.	{ NaNO <sub>3</sub> ... ..	6.6 g.
	{ Compost (a) sterilized <sup>1)</sup>	30.0 „
VI.	{ NaNO <sub>3</sub> ... ..	6.6 „
	{ Compost (b) not sterilized...	30.0 „
VII.	{ NaNO <sub>3</sub> ... ..	6.6 „
	{ Rape cake ... ..	10.0 „
VIII.	Starch ... ..	10.0 „
IX.	Compost (a) sterilized ... ..	30.0 „
X.	Compost (b) not sterilized ... ..	30.0 „
XI.	Rape cake ... ..	10.0 „
XII.	Control ... ..	—

As general manure 5 g of Na<sub>2</sub>HPO<sub>4</sub> and of K<sub>2</sub>SO<sub>4</sub> per pot were applied. Ten young paddy rice plants of equal size were transplanted into each pot on Sept. 24,<sup>2)</sup> 1905, all pots were kept in the glass house until Nov. 20 and were then removed to a green house kept at 15-30°C. but even here the seeds did not ripen, probably on account of the development of numerous young shoots. The following observations were made Oct. 10 and Feb. 19 when the plants were cut.

1), The compost used in this experiment was well rotten.

2). The transplanting by some obstacle took place later than was desirable.

No. of pots.	Kind of Manures.	Average length of plants (cm.).		Average No. of stalks on Feb. 19.
		Oct. 10.	Feb. 19.	
I.	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ... ..	34.0	66.7	32
II.	NaNO <sub>3</sub> .. ...	30.3	59.9	19
III.	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + NaNO <sub>3</sub> ..	32.7	61.7	27
IV.	NaNO <sub>3</sub> + starch ...	27.0	55.3	19
V.	NaNO <sub>3</sub> + compost (a).	30.3	58.4	22
VI.	NaNO <sub>3</sub> + compost (b).	31.5	55.0	20
VII.	NaNO <sub>3</sub> + rape cake ...	31.2	54.3	22
VIII.	Starch only ... ..	28.2	50.7	17
IX.	Compost (a) only ...	27.9	52.0	17
X.	Compost (b) only ...	29.1	53.6	15
XI.	Rape cake... ..	30.9	55.5	21
XII.	Control ... ..	29.1	52.1	15

Plants in the nitrate pots showed the yellowish green color of the young growing leaves especially in those which received organic manures together with nitrate. The tests showed always much more nitrate (at least more than 3 times as much) in the yellowish leaves than in the normally green ones grown with (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> as a manure. But nitrate could not be observed by Griess' test in the yellowish green leaves.

The photograph taken Feb. 19, 1906, and reproduced on plate XVIII shows clearly the differences of growth. The plants weighed in the air dry state gave the following result :

No. of pots.	Kind of Manures.	Average weight p. pot in air dry state (g).			Gain of yield p. pot by soluble N. <sup>1)</sup>	
		Grain(empty)	Straw.	Total.	g	Ratio.
I.	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ... ..	2.570	54.430	57.00	31.50	100
II.	NaNO <sub>3</sub> .....	1.485	30.015	31.50	6.00	19
III.	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + NaNO <sub>3</sub> ..	2.170	40.210	42.38	16.88	54

1). The gain of N by soluble N-salts was calculated by subtracting the yield of control pot from those of pot I, II, and III, the yields of VIII, IX, X and XI from those of IV, V, VI and VII respectively.

No. of pots.	Kind of Manures.	Average weight p. pot in air dry state (g).			Grain of yield p. pot by soluble N. <sup>1)</sup>	
		Grain (empty),	Straw.	Total.	g	Total.
IV.	NaNO <sub>3</sub> +Starch ...	1.690	23.050	24.75	1.50	5
V.	NaNO <sub>3</sub> +Compost (a)	2.560	25.940	28.50	6.00	19
VI.	NaNO <sub>3</sub> +Compost (b)	1.630	23.810	25.50	4.12	14
VII.	NaNO <sub>3</sub> +Rape cake..	1.913	32.587	34.50	2.50	8
VIII.	Starch only ... ..	0.950	22.270	23.25	—	—
IX.	Compost (a) only ...	1.307	21.193	22.50	—	—
X.	Compost (b) only ...	1.190	20.190	21.38	—	—
XI.	Rape cake only ...	1.987	30.013	32.00	—	—
XII.	Control ... ..	1.263	24.237	25.50	—	—

The amounts of the total nitrogen in the air dry samples (after Kjeldahl determined), the gain of nitrogen by the application of ammonia and nitrate N were as follows :

No. of pots.	Kind of Manures.	Content of total N.		Gain of N p. pot by soluble N.	
		%	g	g	Ratio.
I.	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ... ..	0.711	0.405	0.209	100
II.	NaNO <sub>3</sub> ... ..	0.782	0.246	0.050	24
III.	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> +NaNO <sub>3</sub> ..	0.743	0.315	0.119	57
IV.	NaNO <sub>3</sub> +Starch ...	0.743	0.184	0.018	9
V.	NaNO <sub>3</sub> +Compost (a)	0.705	0.201	0.070	33
VI.	NaNO <sub>3</sub> +Compost (b)	0.662	0.169	0.044	21
VII.	NaNO <sub>3</sub> +Rape cake ..	0.716	0.247	0.019	9
VIII.	Starch only ... ..	0.713	0.166	—	—
IX.	Compost (a) only ...	0.583	0.131	—	—
X.	Compost (b) only ...	0.585	0.125	—	—
XI.	Rape cake only ...	0.712	0.228	—	—
XII.	Control ... ..	0.768	0.196	—	—

These results show that the efficiency of nitrate nitrogen for the paddy rice is very unsatisfactory and that the simultaneous application of certain organic matters depresses the yield still further. Well rotten compost exerts a less depressing influence than fresh rape cake.

### VEGETATION EXPERIMENT III.

In order to compare, now, dry land with paddy field in regard to the effect of their different degree of denitrification, the following experiment with buckwheat was made: 36 zinc pots of ca. 25 cm. in diameter were filled with 14 Kg humy soil from Nishigahara. The kind and the amount of manures applied were the same as in the vegetation experiment II. 31 seeds of buckwheat were sown Aug. 27, 1905, and 2 weeks after germination the young plants were reduced to 25 per pot all of equal size. The average height of plants measured Oct. 1 was as follows:

No. of pots.	Kind of Manures.	Average length of plants.
I.	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ... ..	70.3 cm.
II.	NaNO <sub>3</sub> ... ..	70.0 "
III.	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> +NaNO <sub>3</sub> ... ..	71.5 "
IV.	NaNO <sub>3</sub> +Starch ... ..	73.0 "
V.	NaNO <sub>3</sub> +Compost (a) ... ..	72.4 "
VI.	NaNO <sub>3</sub> +Compost (b) ... ..	76.4 "
VII.	NaNO <sub>3</sub> +Rape cake ... ..	74.8 "
VIII.	Starch only... ..	60.6 "
IX.	Compost (a) only ... ..	63.0 "
X.	Compost (b) only ... ..	64.8 "
XI.	Rape cake only ... ..	72.7 "
XII.	Control... ..	60.9 "

The plants were cut Oct. 25 and weighed in the air dry state with the following result:



No. of pots.	Kind of Manures.	Weight of seeds (g).		Weight of stalks (g).		Total yield (g).	
		p. pot.	Average.	p. pot.	Average.	p. pot.	Average.
I.	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	a) 28.88		15.38		44.26	
		b) 22.13	25.13	14.25	15.13	36.38	40.26
		c) 24.38		15.75		40.13	
II.	NaNO <sub>3</sub>	a) 25.88		16.50		42.38	
		b) 27.01	26.51	16.13	16.25	43.14	42.76
		c) 26.63		16.13		42.76	
III.	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + NaNO <sub>3</sub>	a) 27.76		17.25		45.01	
		b) 26.25	27.00	15.38	16.63	41.63	43.63
		c) 27.01		17.25		44.26	
IV.	NaNO <sub>3</sub> + Starch	a) 18.73		13.50		32.25	
		b) 20.25	20.26	15.38	14.50	35.63	34.76
		c) 21.76		14.63		36.39	
V.	NaNO <sub>3</sub> + Compost (a)	a) 26.25		17.63		43.88	
		b) 27.75	26.25	21.38	19.38	49.13	45.63
		c) 24.75		19.13		43.88	
VI.	NaNO <sub>3</sub> + Compost (b)	a) 21.76		16.88		38.64	
		b) 21.38	22.63	17.63	17.63	39.01	40.26
		c) 24.76		18.38		43.14	
VII.	NaNO <sub>3</sub> + Rape cake	a) 27.00		18.00		45.50	
		b) 28.51	27.50	18.00	17.75	46.51	45.25
		c) 27.01		17.25		44.26	
VIII.	Starch only	a) 8.26		8.25		16.51	
		b) 9.01	8.75	7.88	8.00	16.89	16.75
		c) 9.00		7.88		16.88	

No. of pots.	Kind of Manures.	Weight of seeds (g).		Weight of stalks (g).		Total yield (g).	
		p. pot.	Average.	p. pot.	Average.	p. pot.	Average.
IX.	Compost (a) only	a) 12.01		10.13		22.14	
		b) 12.38	11.76	10.88	10.38	23.26	22.14
		c) 10.88		10.13		21.01	
X.	Compost (b) only	a) 13.88		11.25		25.13	
		b) 12.00	12.75	10.88	11.13	22.88	23.88
		c) 12.38		11.25		23.63	
XI.	Rape cake only	a) 23.25		13.88		37.13	
		b) 21.00	21.75	12.38	13.38	33.38	35.13
		c) 21.00		13.88		34.88	
XII.	Control	a) 12.01		9.75		21.76	
		b) 11.63	11.88	10.13	10.00	21.76	21.88
		c) 12.00		10.13		22.13	

To observe the effect of the several organic manures upon denitrification more clearly, a calculation was made by subtracting the yield of pot XII from those of I, II and III, and from the yields of IV, V, VI, VII, those of VIII, IX X and XI respectively with the following result :

No. of pots.	Kind of Manures.	Surplus yield by soluble N-salts.			
		Seeds.		Total yield.	
		g	Ratio.	g	Ratio.
I.	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> .....	13.25	90	18.38	88
II.	NaNO <sub>3</sub> .....	14.63	100	20.88	100
III.	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> +NaNO <sub>3</sub> .....	15.12	103	21.75	104
IV.	NaNO <sub>3</sub> +Starch .....	11.51	78	18.01	86
V.	NaNO <sub>3</sub> +Compost (a) .....	14.40	99	23.49	112
VI.	NaNO <sub>3</sub> +Compost (b) .....	11.87	87	16.38	78
VII.	NaNO <sub>3</sub> +Rape cake .....	5.75	39	10.12	48

This result shows again that the well rotten compost when sterilized has no depressing effect upon the efficiency of nitrate-N, while when not sterilized it depresses the yield very much, owing certainly to the importation of denitrifying organisms into the soil. The efficiency of nitrate-N is also much depressed by the simultaneous application of rape cake.

### CONCLUSIONS.

(1). When nitrate is applied to the paddy soil it is reduced to some extent first to nitrite and then to ammonia and to elementary N, the loss of which varies according to the species of denitrifying organisms and the amount of soluble organic compounds present originally in the soil.

(2). When nitrate is applied to the paddy soil together with much organic matter in easily available form for microbes such as glycerine, Na-acetate, starch, fresh oil cakes and straw, it is destroyed extensively by denitrification, the most part of its nitrogen being lost as free N, while only a certain portion of it remains in the soil, being partly assimilated by microbes and partly absorbed as ammonia by the soil or plants.

(3). The question why nitrate is not a favorable manure for plants grown in paddy land can be answered as follows :

- a). The *loss of N by denitrification* is larger in paddy soil than in dry land.
- b). More of the *poisonous nitrites* are formed there than in dry land.<sup>1)</sup>
- c). *Loss of nitrate* takes place easily by the system of *irrigation*, practiced with paddy plants, being inevitable in the farmers practice.

(4). Dry land surface soil when no organic manures are applied along with nitrate,<sup>2)</sup> does not favor denitrification nor nitrite-formation while in the subsoil reduction occurs to some extent. In very moist conditions, however, as in the rainy season and especially when much organic manure is applied along with nitrate, some denitrification takes place even in top-

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1). Young rice plants placed in a potassium nitrite solution of 0.1% died after 5 days.

2). According to *Amfoku* calcium nitrate is less attacked by denitrifying microbes than sodium or potassium nitrate, but in most soils calcium nitrate added will surely be changed by alkali-salts and nitrates of sodium or potassium be formed.

soil and the reduction can proceed so energetically in the sub-soil that all the nitrate applied may be reduced within a few weeks.

(5). Organic matters easily available to microbes favor denitrification to a large extent; further, straw or fresh rape cakes have more influence upon the reduction of nitrate than the same materials well rotten, which agrees with former observations on stable manure.

### PRACTICAL SUGGESTIONS.

(1). The Chili-saltpetre is no suitable fertilizer for plants grown in paddy soil.

(2). When Chili-saltpetre is to be used for paddy plants, organic manures should not be applied along with it, hence artificial mixed fertilizers composed of Chili-saltpetre and some organic substances are to be avoided for paddy fields.

(3) When however an organic fertilizer is unavoidably to be used along with Chili-saltpetre for paddy plants, the former should be used only in a well rotten state.

In conclusion, the authors express their hearty thanks for valuable suggestions and advice given by the Director Prof. Y. Kozai and Prof. Dr. O. Loew and for the analytical service given by Assistant Mr. C. Matsuoka.

A. Soil from Nishigahara.



(3)  $\text{NaNO}_3$ +glycerine. (2)  $\text{NaNO}_3$ . (1)  $(\text{NH}_4)_2\text{SO}_4$ .

B. Soil from Arakawa.



(3)  $\text{NaNO}_3$ +glycerine. (2)  $\text{NaNO}_3$ . (1)  $(\text{NH}_4)_2\text{SO}_4$ .



Vegetation Experiment II (a).



Vegetation Experiment II (b).



No. 1. =  $(\text{NH}_4)_2\text{SO}_4$

No. 2. =  $\text{NaNO}_3$ .

No. 3. =  $(\text{NH}_4)_2\text{SO}_4 + \text{NaNO}_3$ .

No. 4. =  $\text{NaNO}_3 + \text{Starch}$ .

No. 5. =  $\text{NaNO}_3 + \text{Compost (a)}$ .

No. 6. =  $\text{NaNO}_3 + \text{Compost (b)}$ .

No. 7. =  $\text{NaNO}_3 + \text{Rape cake}$ .

No. 8. = Rape cake only.

No. 9. = Compost (a) only.

No. 10. = Compost (b) only.

No. 11. = Starch only.

No. 12. = Control.





# Influence of Stimulating Compounds upon the Crops under Different Conditions.

BY

S. UCHIYAMA.

**Introductory Remarks.** A series of observations which have been carried on since 1902 at the College of Agriculture, Imperial Univ. Tokyo, have demonstrated that certain mineral salts applied in small doses cause stimulation of development. Special attention was paid to the action of manganese salt,<sup>1)</sup> potassium iodide and sodium fluoride. Manganese occurs sometimes in considerable quantities in plant ashes and the presence of iodine, and fluorine in very small doses must be assumed in plants, to judge from their presence in animal organs. The degree of stimulation however varied considerably with different plant species and also with the manuring conditions. It was therefore necessary to extend the observations in this line in order to collect further information. I have carried out field experiments as well as pot experiments with varying manures and application of manganese with the general manure as well as in the form of top-dressing.

The soil serving for the field experiments was a diluvial loam rich in humus and containing 0.389 % N in the dry fine earth. The dry fine earth amounted to 97.70 % and showed the following composition :

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1). The stimulating effect of manganese salt has since been confirmed by Bertrand and several other authors. Bertrand calls such compound beneficial in small doses: supplementary manures.

	Soluble in		
	10 % Hcl at 98°C.	1% Hcl at room temperature after 7 days.	1% citric acid after Dyer.
Al <sub>2</sub> O <sub>3</sub>	11.961	4.412	0.289
Fe <sub>2</sub> O <sub>3</sub>	8.552	0.141	0.299
Mn <sub>3</sub> O <sub>4</sub>	0.413	0.293	0.076
CaO	0.831	0.434	0.392
MgO	1.202	0.168	0.117
K <sub>2</sub> O	0.143	0.023	0.019
Na <sub>2</sub> O	0.097	0.017	0.014
P <sub>2</sub> O <sub>5</sub>	0.276	0.011	0.033
SO <sub>3</sub>	0.191	0.012	0.019
SiO <sub>2</sub>	0.215	1.169	0.521

For the pot experiments, beside the above soil, also an alluvial sandy soil poor in organic matter was used, (0.135 % N in the dry fine earth) yielding 96.05 % dry fine earth of the following composition :

	Soluble in		
	10 % Hcl at 98°C.	1% Hcl at room temperature after 7 days.	1% citric acid after Dyer.
Al <sub>2</sub> O <sub>3</sub>	3.787	0.351	0.095
Fe <sub>2</sub> O <sub>3</sub>	4.830	1.189	0.518
Mn <sub>3</sub> O <sub>4</sub>	0.290	0.134	0.054
CaO	0.718	0.398	0.247
MgO	1.177	0.313	0.116
K <sub>2</sub> O	0.158	0.021	0.012
Na <sub>2</sub> O	0.095	0.021	0.018
P <sub>2</sub> O <sub>5</sub>	0.172	0.030	0.025
SO <sub>3</sub>	0.056	0.011	0.012
SiO <sub>2</sub>	0.387	0.438	0.302

A. STIMULATING ACTION OF MANGANESE.

A). Field Experiment.

1). Experiment with Barley and Wheat.

Four plots (area =  $\frac{1}{100}$  ha.), received the following manures, each :

	Ratio per ha. (kilo.)	
	for Barley	for Wheat
Compost ... ..	7308	3657
Common superphosphate ... ..	165	165
Straw-ash ... ..	219	219
Mixed human excreta ... ..	2789	2088

On Oct. 4, 1903, the seeds were sown at the rate of 50 kilo. barley and 42 kilo. wheat per ha. To each plot of barley and wheat manganous sulphate was applied as top-dressing in high dilution in four fractional doses (Oct. 26, Jan. 11, March 7, April 12) so that the total amount corresponded to 33.2 kilo.  $Mn_3O_4$  per ha., while at the same time the other two plots received the same doses of water.

At the first application of the manganous sulphate, the plants were about 10 cm. high. During vegetation, the treated plants developed somewhat more luxuriantly. On June 8, the plants were cut. The weight in the air-dry state was, kilo. :

	plots.	Grains.	Straw.	Total.	Comparative Yield Grains of check plot = 100.
Barley	A Check	41.32	69.50	110.82	100
	B $MnSO_4$	43.95	69.62	113.57	106
Wheat	A Check	28.36	45.45	73.81	100
	B $MnSO_4$	30.99	47.34	78.33	109

This result shows that the dose of 33.2 kilo.  $Mn_3O_4$  per ha. had but a very moderate effect on barley and wheat in this case.

## 2). Experiment with Grasses.

The grasses serving for this experiment were alsike clover (or Swedish Clover, *Trifolium hybridum*), Creeping Soft-grass (*Holcus mollis*) and Meadow Soft-grass (*Holcus lanatus*). Six plots, each measuring 4.96 square meters received the following manures :

For Gramineæ=4.5 kilo. human urine + 72g secondary sodium phosphate,

„ Leguminosæ=53g. potassium sulphate + 94g „ „ „

Manganese sulphate was applied at the rate of 25 kilo.  $Mn_2O_4$  per ha. in solution in three fractions, i.e. Oct. 29, Jan. 11 and Mar. 10. The treated plants seemed continuously somewhat superior to the check plants. The plants were cut in 2-3 fractions, i.e. June 9, July 16 and Aug. 19 with the following result, kilo. :

			First Crop.	Second Crop.	Third Crop.	Total.
Fresh state	Alsike Clover	Check plant	7.737	8.188	—	15.925
		Treated „	9.578	9.728	—	19.306
	Creeping Soft-grass	Check „	11.268	4.582	1.315	17.165
		Treated „	12.921	4.733	2.141	19.795
	Meadow Soft-grass	Check „	12.883	9.615	1.540	24.038
		Treated „	13.860	12.395	2.441	28.696
Air-dry state	Alsike Clover	Check „	1.352	2.254	—	3.606
		Treated „	1.728	2.592	—	4.320
	Creeping Soft-grass	Check „	2.704	1.164	0.376	4.244
		Treated „	3.230	1.239	0.639	5.108
	Meadow Soft-grass	Check „	2.216	1.878	0.413	4.507
		Treated „	2.479	2.554	1.052	6.085

If now we assume the total yield of the check plants respectively to be = 100, we obtain the following ratio :

	Alsike clover.	Creeping Soft-grass.	Meadow Soft-grass.
Check plants ... ..	100	100	100
Treated plants... ..	120	120	135

The effect of manganese sulphate was here very favorable.

3). Experiment with Buckwheat.

Three plots, each having an area of 33.1 square meters were manured Aug. 27 at the rate of 9000 litres human excreta, 375.7 kilo. straw ash and 225.4 kilo. common superphosphate per ha. Manganous sulphate was applied at the rate of 20 kilo. per ha., as follows :

Plot I. received no  $MnSO_4$ ,

Plot II. ,,  $MnSO_4$  together with the manure, i.e. Aug. 27.

Plot III. ,, ,, as top-dressing in two fractions, i.e. Sept. 8 and 22.

On Aug. 29, the seeds were sown at the rate of 90 kilo. per ha. The plants in plot II developed more luxuriantly in the beginning, while those in plot III excelled the former later on. The crop was harvested Nov. 1 and weighed in the air-dry state with the following result, kilo. :

	Grains.	Straw.	Total.	Comparative Yield	
				grains.	Total.
I. Control ... ..	2.021	1.397	3.418	100	100
II. $MnSO_4$ together with manure	2.216	1.529	3.745	110	110
III. $MnSO_4$ as top-dressing... ..	2.367	1.773	4.140	117	121

This result shows that the manganese sulphate exerted a considerable stimulating influence on buckwheat when applied in the form of top-dressing, while the simultaneous application with the manure was much less favorable.

## 4). Experiment with Egg plant.

Two plots, each having an area of  $\frac{1}{200}$  ha., were manured with 4.22 kilo. ammonium sulphate, 2.51 kilo. common superphosphate and 1.59 kilo. potassium sulphate. On May 6, sixty young plants were transplanted to each plot. To one plot, manganese chloride was applied at the rate of 10 kilo.  $Mn_2O_4$  per ha. as top-dressing in three fractions, i.e. July 1, July 28 and Aug. 19. The fruits of the egg plants were harvested at several periods when they became properly ripe as usual, and weighed in the fresh state with the following result :

Date of harvest.	Control-plot.		MnCl <sub>2</sub> -plot.	
	No. of fruit.	Weight of fruit(g).	No. of fruit.	Weight of fruit(g).
July 15 ... ..	41	2873.7	33	2768.5
„ 18 ... ..	2	89.2	4	179.3
„ 20 ... ..	4	170.65	4	185.57
„ 24 ... ..	19	1144.1	16	991.5
„ 27 ... ..	13	756.23	19	1208.02
„ 28 ... ..	44	2499.5	44	2378.7
Aug. 1 ... ..	25	2016.96	31	2432.45
„ 5 ... ..	30	2490.18	43	3509.87
„ 8 ... ..	40	3662.25	35	3202.15
„ 10 ... ..	38	3123.89	19	1564.4
„ 15 ... ..	32	3747.71	55	6413.69
„ 18 ... ..	78	6967.0	82	7237.0
„ 19 ... ..	54	2582.0	117	5743.0
„ 21 ... ..	32	1084.0	21	628.0
„ 24 ... ..	24	942.1	30	1358.1
„ 28 ... ..	116	4327.0	67	2670.0
„ 30 ... ..	25	662.5	19	392.5
„ 31 ... ..	68	1709.0	74	1892.5
Sept. 4 ... ..	78	1983.0	69	2652.0
„ 6 ... ..	135	2943.0	123	2772.0

Date of harvest.	Control-plot.		MnCl <sub>2</sub> -plot.	
	No. of fruit.	Weight of fruit(g).	No. of fruit.	Weight of fruit(g).
Sept. 8 ... ..	117	2628.0	105	1747.5
„ 11 ... ..	102	1902.0	87	1830.0
„ 13 ... ..	36	630.0	57	990.0
„ 15 ... ..	345	7152.0	375	8220.0
„ 21 ... ..	120	1956.0	90	1788.0
„ 25 ... ..	90	1368.0	93	1908.0
„ 29 ... ..	105	1920.0	159	2850.0
Oct. 3 ... ..	132	1608.0	132	1434.0
„ 7 ... ..	435	2907.0	615	4056.0
Sum ... ..	2380	67844.97	2618	75002.75

The plants were then plucked out, and the stalks with the roots were weighed in the fresh state with the following result, kilo. :—

	Stalks and roots.
Control plot ... ..	35.44
Treated „ ... ..	41.57

The following table shows conveniently the total harvest, kilo. :

	Fruit.	Stalks and roots.	Total.	Comparative Yield.	
				Fruit.	Stalks & roots.
I. Control plot ... ..	67.84	35.44	103.28	100	100
II. Trade plot ... ..	75.00	41.57	116.57	111	117

Manganese chlorid exerted therefore here a favorable effect.

### 5). Experiment with Tea-plants.

For this experiment, two small plots were selected from our tea-farms ; the plants on these plots were of about equal development. Each plot, having an area of 1/375 ha. was manured with

28.40 kilo. human excreta	}	in the preceding autumn,
3.98 „ rice-bran		
2.97 „ fish manure (herring)		
1.50 „ herring in the early spring.		

To one plot, manganous sulphate was applied at the rate of 37.5 kilo.  $Mn_3O_4$  per ha. as top-dressing in three portions, i. e. Oct. 9, March 11 and April 12. In the beginning of May, the leaves of the manganese plants showed a darker green color. The leaves were picked out on May 17, and weighed in the fresh state with the following result, kilo. :

	Yield of Leaves.	Comparative Yield.
I. Control... ..	14.25	100
II. $MnSO_4$ ...	18.38	129

Manganous sulphate exerted here a great influence on the leaf formation of the tea-plants.

#### 6). Second Experiment with Tea-plants.

In this experiment, manganese sulphate was tested with the development of young tea-plants for two successive years. For this purpose, nine plots (area =  $\frac{1}{2200}$  ha.) were selected from our experimental field of a diluvial loam rich in humus. Three plots received only manures, and the other three received manures + manganese sulphate, while another set of three plots remained without any application of manures as follows :

- A No manure.
- B Manure.
- C Manure and manganese sulphate.

In the beginning of March, 1904, four wide holes were prepared in each plot : and to each hole of the plots B and C, 2.7 kilo. putrid excreta were applied. Two weeks later, each hole received 20 seeds of tea plants previously steeped in water ; thus each plot had four bundles of tea-plants. In the following spring, the young plants were reduced to eight per bundle of about equal size.



Experiment in the First Year:

Each bundle of the plots B and C was manured with 2 litres putrid urine, April 15, 1905. Manganese sulphate was applied to each bundle of the plots C at the rate of 20.3 kilo. per ha. as top-dressing in five fractions, i.e. April 20, May 2, 13, 22, and June 5. The plants of the plots C looked continuously better than those of the other plots. The following table shows the height of plants Nov. 10, 1905:

Average of each twelve bundles.

Plots.	Height of plants, cm.
A No manure ... ..	32.4
B Manure ... ..	36.7
C Manure + MnSO <sub>4</sub> ... ..	38.5

The adjoining plate XX shows the development, Nov. 10. Two bundles of each plot were then plucked out Nov. 1, and weighed with the following result, g.:

Average of two bundles.

		Leaves.	Stems and branches.	Roots.	Total.
Fresh state	A No manure ... ..	82.4	64.1	94.5	241.0
	B Manure ... ..	111.2	85.4	127.2	323.8
	C Manure + MnSO <sub>4</sub> ...	124.8	95.4	125.9	346.1
Air-dry state	A No manure ... ..	40.0	31.2	32.7	103.9
	B Manure ... ..	52.7	41.4	28.93	132.4
	C Manure + MnSO <sub>4</sub> ...	61.3	47.7	28.38	152.2

If we now assume the total yield of the plots B in the air-dry state to be = 100, we obtain the following ratio :

Plots.	Total Comparative Yield.
A No manure ... ..	78
B Manure ... ..	100
C Manure + MnSO <sub>4</sub> ... ..	115

Thus, it can be recognized that manganese sulphate favored the development of young tea-plants.

#### Experiment in Second Year :

In the following spring, the remaining bundles of the plots B and C were manured each with 75.59 g. ammonium sulphate, 25.64 g. secondary sodium phosphate and 21 g. potassium sulphate. To each bundle of the plots C, manganese sulphate was applied at the rate of 12.19 kilo. per ha. as top-dressing in three fractions, i.e. April 13, May 29, and July 12. The manganese plants showed continuously a better development. The following table shows the height of plants on Nov. 22, 1906 :

#### Average of each ten bundles.

Pots.	Height of plants, cm.
A No manure ... ..	53.0
B Manure ... ..	70.3
C Manure + MnSO <sub>4</sub> ... ..	72.4

The adjoining plate XX shows the development, Nov. 22. Two bundles of each plot were then plucked out No. 22, with the following result, g. :

## Average of two bundles.

	Pots.	Leaves.	Stems and branches.	Roots.	Total.
Fresh state	A No manure ... ..	191.0	236.5	250.5	487.0
	B Manure ... ..	325.0	480.5	419.0	1224.5
	C Manure + MnSO <sub>4</sub> ...	393.0	498.0	428.0	1319.0
Air-dry state	A No manure ... ..	80.0	117.0	95.5	292.5
	B Manure ... ..	135.0	222.0	177.0	534.0
	C Manure + MnSO <sub>4</sub> ...	179.5	239.5	211.5	630.5

The total comparative yield in the air-dry state is calculated as follows :

Plots.	Total Comparative Yield.
A No manure ... ..	55
B Manure ... ..	100
C Manure + MnSO <sub>4</sub> ... ..	118

Manganese sulphate had also here acted favorably on the development of young tea-plants.

## 7). Experiment with Radish.

Two plots, each having an area of  $1/200$  ha., were manured at the rate of

- 10500 kilo. compost,
- 450 ,, common superphosphate,
- 750 ,, straw ash and
- 7494 litres human excreta, per ha.

On Oct. 21, 1904, the seeds were sown, and the number of shoots was afterward reduced to 280 per plot. To one plot, manganous sulphate was applied at the rate of 20 kilo. per ha. as top-dressing in three portions, i.e.

Feb. 7, 18 and March 29, the first application being made when the young plants had reached about 10 cm. On April 18, some decisive difference could be clearly observed, the treated plants showing a more luxuriant and darker green appearance.

The plants were harvested May 2, and weighed in the fresh state with the following results, kilo. :

	Roots.	Leaves.	Total.	Comparative Yield.	
				Roots.	Leaves.
Check plants ... ..	144.49	78.88	223.37	100	100
Treated plants ... ..	175.41	94.65	270.06	121	120

Manganous sulphate had acted very favorably.

#### 8). Second Experiment with Radish.

Manganous sulphate was here tested in two different applications, i.e. mixed with manure, and as top-dressing. The manganous sulphate was applied in each case at the rate of 20 kilo. per ha. Three plots, each having an area of  $1/278$  ha., were manured with 93.75 kilo. Compost, 62.63 kilo. human excreta, 3 kilo. common superphosphate and 6.26 kilo. straw ash. To one plot, the whole dose of manganous sulphate was then applied in solution. On Oct. 21, 1904, the seeds were sown, and the young plants were afterward reduced to 300 per plot. Manganous sulphate was applied to the other one plot as top-dressing in three portions i.e. Dec. 12, Feb. 18 and March 7. At the flowering period, the plants supplied with top-dressing of manganous sulphate showed a more luxuriant growth.

The plants were harvested on June 28, and weighed in the air-dry state with the following result, kilo. :

	Grains.	Hucks.	Stalks and Roots.	Total.	Comparative yield.	
					Grains.	Total.
I. Control ... ..	6.01	9.25	10.10	25.36	100	100
II. $MnSO_4$ together with manure...	6.22	10.01	9.91	26.14	104	103
III. $MnSO_4$ as top-dressing ... ..	6.47	11.52	10.08	28.07	108	111

Hence it can be seen also here that manganous sulphate acts more effectively when applied as top-dressing than when mixed with the main manures.

9). Experiment with Beans.

Three plots, each having an area of 1/278 ha., were manured with 93.75 kilo. Compost, 31.13 kilo. human excreta, 1.58 kilo. common superphosphate and 3.11 kilo. straw ash. Manganous sulphate was applied at the rate of 20 kilo. per ha. The second plot received the whole dose of manganous sulphate a few days after the application of the general manures, while for the third plot it was applied as top-dressing in three fractional doses. On Oct. 21, 1904, the seeds were sown, and the number of shoots was afterward reduced to 300 per plot.

The plants were harvested June 26, and weighed in the air-dry state with the following result, kilo. :

	Grains.	Stalks and		Comparative yield.	
		Hucks.	Total.	Grains.	Total.
I. Control ... ..	11.88	28.55	40.43	100	100
II. MnSO <sub>4</sub> together with manure ...	14.98	33.10	48.08	126	119
III. MnSO <sub>4</sub> as top-dressing ... ..	17.11	36.77	53.88	144	133

Manganese sulphate acted here very favorably and better in the form of top-dressing.

10). Experiment with *Brassica Campestris*, *Cul. Var. Hakusai*.

Three plots, each having an area of 1/400 ha., were manured with 26.25 kilo. compost, 16.20 kilo. human excreta, 1.88 kilo. straw ash, and 1.13 kilo. common superphosphate. Manganous sulphate was applied at the rate of 20 kilo. per ha. One plot received the whole dose of manganous sulphate a few days after the application of the general manures. To the other plot, manganous sulphate was applied as top-dressing in two fractions, i.e. Sept. 28, and Oct. 8. On Sept. 8, 1904, the seeds were sown, and the young shoots afterwards reduced to 240 per plot. The plants were harvested Nov. 24, and weighed in the fresh state with the following result, kilo. :

	Total yield.	Comparative yield.
I. Control... ..	136.42	100
II. MnSO <sub>4</sub> together with manure ... ..	147.38	108
III. MnSO <sub>4</sub> as top-dressing ... ..	154.80	114

Manganese sulphate had favored the development of *Brassica campestris*, especially in the form of top-dressing.

11). Experiment with *Brassica Campestris*, cul. var. *Mikawashima-na*.

Three plots, each having an area of 1/278 ha., manured with 93.75 kilo. compost, 62.63 kilo. human excreta, 3 kilo. common superphosphate and 6.26 kilo. straw ash. Manganous sulphate was applied at the rate of 20 kilo. per ha. One plot received the whole dose of manganous sulphate a few days after the application of the general manures, while the third plot received it as top dressing, Dec. 12, Feb. 18 and March 7. On Oct. 21, 1904, the seeds were sown, and the number of shoots afterwards reduced to 375 per plot.

The plants were harvested on March 27, and weighed in the fresh state with the following result, kilo. :

	Total yield.	Comparative yield.
I. Control ... ..	82.31	100
II. MnSO <sub>4</sub> together with manure ... ..	92.38	110
III. MnSO <sub>4</sub> as top-dressing ... ..	101.06	123

This result is quite in accordance with that of the preceding experiment.

12). Third Experiment with Radish.

An experiment made by Prof. Loew<sup>1)</sup> with tobacco had shown that the simultaneous application of manganese and iron salts exerted a better effect on the development than when each of these salts was applied alone. Under certain circumstances, it may occur however that the simultaneous application of both those salts is not so advantageous as when each is

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applied alone. On soils rich in manganese and poor in iron, the result will differ from that on soils poor in manganese and rich in iron. In order to collect further material, therefore, we have observed the effects of top-dressing with both sulphates upon radish.

- Plot I. Control,
- „ II. Ferrous sulphate alone, 20 kilo. per ha.
- „ III. Ferrous sulphate + manganous sulphate, 20 kilo. each per ha.
- „ IV. Manganous sulphate alone, 20 kilo. per ha.

To each plot measuring 17.5 square meter, the following manures were applied :

Compost ... ..	10500 kilo.	} per ha.
Common superphosphate ... ..	450 „	
Straw ash ... ..	750 „	
Human excreta ... ..	6494 litres	

On August 8, 1904, the seeds were sown, and the number of shoots afterwards reduced to 60 per plot. After the young plants had reached about 10 cm., they received the top-dressing of manganous and ferrous sulphate at the following dates :

- On Aug. 26, 7.056 g. salt in 0.1303 <sup>0</sup>/<sub>100</sub> solution,
- „ Sept. 5, 10.583 g. „ „ 0.1955 <sup>0</sup>/<sub>100</sub> „
- „ „ 22, 17.939 g. „ „ 0.3259 <sup>0</sup>/<sub>100</sub> „

On Sept. 5, some decisive difference could be clearly noticed, the treated plants showing a more luxuriant and darker green appearance.

The plants were harvested on Oct. 7, and the roots as well as the leaves were weighed in the fresh state with the following results, kilo. :

	Roots.	Leaves.	Total	Comparative yield.	
				Roots.	Leaves.
I. Control... ..	23.850	20.925	44.775	100	100
II. FeSO <sub>4</sub> ... ..	30.000	23.963	53.963	126	115
III. FeSO <sub>4</sub> + MnSO <sub>4</sub> ... ..	30.825	25.313	56.138	129	121
IV. MnSO <sub>4</sub> ... ..	32.100	25.950	58.050	135	124

The adjoining plate XXI exhibits the differences very clearly. Stimulation was therefore caused on the three plots and the result of joint

application of both sulphates remained between that obtained with ferrous sulphate and manganous sulphate alone.

13). Experiment with up-land rice.

Manganous sulphate was here applied in conjunction with ferrous sulphate. Two plots, each measuring  $1/300$  ha. were manured<sup>1)</sup> at the rate of 6385 kilo., compost, 4327 kilo. mixed excrement, 225.4 kilo. soy-bean cake, 112.7 kilo. straw ash and 225.4 kilo. common superphosphate per ha. The seeds (100 g.) of upland rice were then sown May 10, 1904. To one plot, solutions of manganous sulphate and ferrous sulphate were applied as top-dressing in three fractions so that the total doses of each salt amounted to 15 kilo., each per ha.; while at each respective period, water, corresponding to the volume of these solutions was added to the check plot. The first dose of manganous sulphate was applied when the plants were about 10 cm. high. The following table shows the date regarding the application of both these sulphates :

		First dose.	Second dose.	Third dose.
Manganous sulphate... ..	{ Kilo. per ha.... ..	2	5	8
	{ Date ... ..	June 2	June 18	July 20
Ferrous sulphate ... ..	{ Kilo. per ha.... ..	2	5	8
	{ Date ... ..	June 9	June 26	July 20

During vegetation, the plants treated with both sulphates showed a somewhat better development.

The plants were cut Sept. 10, and weighed in the air-dry state with the following result, kilo. :

	Grains.	Straw.	Chaffs.	Total.	Comparative yield of grains.
Check plants ... ..	10.86	14.96	0.60	26.42	100
Treated plants ... ..	11.46	16.16	0.65	28.27	106

1). The manuring principals were 76 kilo. nitrogen, 61 kilo. phosphoric acid and 55 kilo. potassa per ha.



This result shows that small doses of manganese and iron applied had but very little, if any stimulating effect. The doses must, for rice at least be increased, an observation made also by Nagaoka with paddy rice.

14). Experiment with Carrots.

Four plots, each having an area of 1/400 ha. received 26.25 kilo. compost, 1.88 kilo. straw ash, 1.14 kilo. soybean cake, and 1.13 kilo. common superphosphate. Manganous and ferrous sulphate were applied at the rate of 20 kilo. each per ha. as top-dressing in three fractions. On July 15, 1904, the seeds were sown, and the number of shoots afterwards reduced to 300 per plot. When the young plants had reached about 10 cm. in height, they received a top-dressing of manganous and ferrous sulphate, i.e. Aug. 18, Sept. 5 and Sept. 22.

The plants were harvested on Nov. 25, and weighed in the fresh state with the following result, kilo. :

	Roots.	Leaves.	Total.	Comparative yield.	
				Roots.	Leaves.
I. Control... ..	37.83	18.75	56.58	100	100
II. FeSO <sub>4</sub> ... ..	38.62	19.33	57.95	102	103
III. FeSO <sub>4</sub> +MnSO <sub>4</sub> ...	45.32	20.33	65.65	120	108
IV. MnSO <sub>4</sub> ... ..	45.53	21.54	67.07	120	115

From the above result, it can be seen that the application of manganous sulphate alone caused an increase of 20% roots, while manganous and ferrous sulphate in joint application led to the same result.

15). Second Experiment with *Brassica Campestris*, *Cul. var. Hakusai*.

Four pots, each having an area of 1/750 ha., were manured with 13.99 kilo. compost, 8.64 kilo. human excreta, 1.09 kilo. straw ash and 0.6 kilo. common superphosphate. On Sept. 8, 1904, the seeds were sown, and the number of shoots was afterward reduced to 180 per plot.

Manganous and ferrous sulphate were applied at the rate of 20 kilo. each per ha. as top-dressing in two fractions, i.e. Sept. 28 and Oct. 8.

During vegetation, the treated plants showed a more luxuriant and darker green appearance. The plants were harvested Nov. 24, and weighed in the fresh state with the following result, kilo. :

	Total yield.	Comparative yield.
I. Control ... ..	57.26	100
II. FeSO <sub>4</sub> . . . . .	66.09	115
III. FeSO <sub>4</sub> +MnSO <sub>4</sub> ... ..	67.59	118
IV. MnSO <sub>4</sub> ... ..	71.16	127

Thus the application of manganous sulphate alone caused an increase of 27%, while manganous and ferrous sulphate in joint application 18% and ferrous sulphate alone 15%.

#### 16). Experiment with Sweet-potatoes.

Two plots, each measuring 1/100 ha. were manured at the rate of 3756 kilo. compost, 563 kilo. straw ash and 113 kilo. common super-phosphate per ha. On May 22, 1904, 330 young shoots were transplanted to each plot. Solutions of manganous sulphate and ferrous sulphate were applied to one plot as top-dressing in three fractions, i.e. July 19, Aug. 2 and Aug. 16 so that the total dose of each salt amounted to each 15 kilo. per ha., while the check plot received only water.

Leaves of the plants treated with sulphates of manganese and iron showed also here a darker green color than those of the check plants. The plants were harvested Nov. 10 and weighed in the fresh state with the following result, kilo. :

	Tubers.	Runners, leaves, etc.	Total.	Comparative yield of tubers.
Check plants ... ..	125.98	227.07	353.05	100
Treated plants ... ..	170.35	247.65	418.00	135

This result shows that the joint application of sulphates of manganese and iron increased the harvest by 35% in tubers.

## 17). Second Experiment with Sweet-potatoes.

Manganous sulphate was here applied separately with ferrous sulphate each at the rate of 15 kilo. per ha. Three plots, each having an area of  $1/100$  ha. were manured with 2.69 kilo. sodium nitrate, 25 kilo. straw ash and 1.29 kilo. secondary sodium phosphate. On May 28, 330 young shoots of potato-plants were transplanted to each plot. The first plot served as a Check, the second received a top-dressing of ferrous sulphate, and the third received manganous sulphate. The sulphates of manganese and iron were applied in solution in three fractions, i.e. July 15, 28 and Aug. 12.

The plants of the plots II and III showed a darker green color and better growth than those of the control plot. The plants were harvested Oct. 25, and weighed in the fresh state with the following result, kilo. :

	Tubers.	Runners.	Total.	Comparative yield of tubers.
I. Control... ..	107.85	245.10	352.95	100
II. FeSO <sub>4</sub> ... ..	131.06	255.11	386.17	121
III. MnSO <sub>4</sub> ... ..	144.68	263.63	408.31	134

This result agree with that of the preceding experiment, showing that sulphate of manganese as well as iron acts very favorably on the yield of sweet potatoes and that manganese was superior to iron.

## B). POT EXPERIMENTS.

1). Experiment with *Polygonum Tinctorium*.

This experiment was carried out in tall zinc bottomless cylinders inserted in the ground. Eight cylinders (area= $1/18180$  ha.) were filled each with 256.8 kilo. air-dry soil, a diluvial loam. Four of them served as check, while the other four received manganese sulphate at the rate of 15 kilo. per ha. On April 15, each cylinder was manured with 60 g. ammonium sulphate, 32 g. secondary sodium phosphate and 26 g. potassium sulphate. Four days later, the seeds of *Polygonum tinctorium* were sown, and the young shoots afterwards reduced 56 per cylinder of about equal

size in seven bundles, each consisting of eight individuals. Dilute solution of manganese sulphate was applied as top-dressing in three portions, i.e. June 6, 16, and 27. During vegetation, the manganese plants looked continuously better than the control plants. The plants were cut in two periods, i.e. the first crop on June 17 and the second on July 4. The following table shows the harvest, g. :—

Average of four Parallel Cylinders.

		Leaves.	Stalks.	Total.	
Fresh state	Control plants	First crop ... ..	999.2	674.7	1673.9
		Second crop ... ..	598.3	539.0	1137.3
		Sum ... ..	<b>1597.5</b>	<b>1213.7</b>	<b>2811.2</b>
	Mn-plants	First crop ... ..	1081.3	774.5	1855.8
		Second crop ... ..	677.3	626.7	1304.0
		Sum ... ..	<b>1758.6</b>	<b>1401.2</b>	<b>3159.8</b>
Air-dry state	Control plants	First crop ... ..	137.0	58.5	195.5
		Second crop ... ..	84.8	71.0	155.8
		Sum ... ..	<b>221.8</b>	<b>129.5</b>	<b>351.3</b>
	Mn-plants	First crop ... ..	153.2	61.9	215.1
		Second crop ... ..	96.7	78.5	175.2
		Sum ... ..	<b>249.9</b>	<b>140.4</b>	<b>390.3</b>

	Control plants.	Manganese-plants.
Ratio of total harvest in leaves (air-dry state)	100	113

Manganese had therefore moderately stimulated the development of *Polygonum tinctorium*.

## 2). Experiment with Buckwheat.

Eight zinc bottomless cylinders (area=1/18180 ha.) inserted in the field were filled each with 256.8 kilo. air-dry soil, a diluvial loam rich in humus. Four of them served as a check, while the other four received manganese sulphate at the rate of 20 kilo. per ha. On June 27, each cylinder was manured with 25 g. ammonium sulphate and 30 g. common superphosphate, and a week later again with 10 g. potassium carbonate. On July 5, eighty-six seeds of buckwheat were sown per cylinder. Manganese sulphate was applied as top-dressing in two fractions, i.e. July 18 and 26. The plants were harvested Sept. 3 with the following result, g. :

Average of four parallel cylinders in the air-dry state.

	Grains.	Straw.	Total.	Comparative yield of Grains.
Control plants ... ..	112.20	147.32	259.52	100
Mn-plants ... ..	122.11	152.02	274.13	109

Thus the plus-yield of the grains of buckwheat caused by the manganese amounted to 9%.

## 3). Experiment with Radish.

Eight zinc bottomless cylinders (area=1/18180 ha.) inserted in the ground were filled each with 256.8 kilo. air-dry soil, a diluvial loam rich in humus. Four of them served as a check, while the other four received manganese sulphate at the rate of 30 kilo. per ha. On Aug. 4, each cylinder was manured with 18.5 g. potassium carbonate, and five days later again with 60 g. ammonium sulphate and 48.1 g. common superphosphate. On Aug. 10, forty five radish seeds were sown per cylinder, and the young shoots were later reduced to three per cylinder of about equal size. Manganese sulphate was applied as top dressing in three fractions, i.e. Sept. 4, 18 and Oct. 1. The plants were harvested on Oct. 20, and weighed in the fresh state with the following result, kilo. :

## Average of four parallel cylinders.

	Roots.	Leaves.	Total.	Comparative yield of roots.
Control plants ... ..	3.563	1.613	5.176	100
Mn-plants ... ..	4.088	1.838	5.926	115

Thus the plus-yield of roots produced by manganese salt was here 15 %.

## 4). Experiment with Barley.

This experiment was carried out with tall zinc bottomless cylinders inserted in the ground. Each cylinder having an area of  $1/95500$  ha. was filled with 26.67 kilo. dry soil, a diluvial loam. Manganese sulphate was applied at the rate of

I.	0	} $Mn_2O_4$ per ha.
II.	10 kilo.	
III.	25 "	
IV.	50 "	
V.	100 "	
VI.	500 "	

For each series, fifteen cylinders were prepared. On Nov. 2, each cylinder received 17.48 g. ammonium sulphate and 8.43 g. common superphosphate and 21.5 g. kainit; and again received 30 seeds of six-sided barley. The young shoots were afterwards reduced to 20 per cylinder of about equal size. Dilute solution of manganese sulphate was applied as top-dressing in three fractions, i.e. March 19, April 17 and May 1.

During vegetation, the plants supplied with the medium dose of manganese sulphate III looked most vigorous. The following table shows the data regarding the growth at May 24:

## Average of fifteen parallel cylinders.

Cylinders.	$Mn_2O_4$ per ha.	Height cm.	No. of stalk.
I.	0	92.7	40
II.	1: kilo.	95.7	41

Cylinder.	Mn <sub>3</sub> O <sub>4</sub> per ha.	Height cm.	No. of stalk.
III.	25 Kilo.	93.0	49
IV.	50 „	93.8	48
V.	100 „	91.7	46
VI.	500 „	89.6	43

The plants were harvested on June 8, and weighed in the air-dry state with the following result, g. :

Average of fifteen parallel cylinders.

Cylinders.	Mn <sub>3</sub> O <sub>4</sub> per ha.	Grain.	Straw.	Chaffs.	Total.	Comparative yield.	
						Grains.	Total.
I.	0	65.8	84.0	5.2	155.0	100	100
II.	10 kilo.	74.8	95.3	6.8	176.9	114	114
III.	25 „	77.8	107.2	7.7	192.7	118	124
IV.	50 „	73.4	101.6	6.8	181.8	112	117
V.	100 „	72.1	97.2	7.0	176.3	110	114
VI.	500 „	67.0	91.4	6.8	165.2	102	107

This result shows that manganese sulphate acts favorably on the yield of barley, the optimum amount being 25 kilo. Mn<sub>3</sub>O<sub>4</sub> per ha., which agrees exactly with the most favorable dose observed by Nagaoka for paddy rice.

5) Experiment with *Panicum Miliacum*.

This experiment was carried out with tall zinc cylinders (bottomless) inserted in the ground. Fourteen cylinders, each having an area of 1/20000 ha., were filled with 18.75 kilo. air-dry soil (an alluvial sand).

The sulphate of manganese and iron were jointly applied as follows :

	Each sulphate applied.	
	Per pot (g.)	Per ha. (kilo.)
I.	0	0
II.	0.047	9.4
III.	0.094	18.8

	Each sulphate applied.	
	Per pot (g.)	Per ha. (kilo.)
IV.	c.141	28.2
V.	c.188	37.6
VI.	c.376	75.2
VII.	c.940	188.0

Each cylinder was manured on June 20 with ammonium sulphate, secondary sodium phosphate and potassium sulphate at the rate of 56.3 kilo. phosphoric acid, and 75 kilo. each of nitrogen and potassa per ha. Three days later, the seeds were sown, and the young shoots reduced to four per cylinder of about equal size. The sulphate of manganese and iron were applied as top-dressing in three fractions, i.e. July. 13, 26 and Aug. 3. The plants supplied with the sulphate of manganese and iron developed gradually better than those of the control cylinders. The plants were harvested on Sept. 5, and weighed in the air-dry state with the following result, g. :

Average of two parallel pots.

Cylinders.	Sulphate of manganese and iron per ha.	Grains.	Straw.	Chaffs.	Total.	Comparative yield.	
						Grains.	Total.
I.	0	22.9	30.7	3.2	56.8	100	100
II.	9.4 kilo.	24.9	33.8	3.1	61.8	109	109
III.	18.8 "	25.8	34.2	4.0	64.0	112	113
IV.	28.2 "	27.3	35.5	5.2	69.0	119	121
V.	37.6 "	26.8	35.2	4.3	66.3	117	117
VI.	75.2 "	25.5	34.0	3.8	63.3	111	111
VII.	188.8 "	23.4	33.5	3.5	60.4	102	106

The joint application of manganese and iron salt acted therefore most favorably with the dose of 28.2 kilo. per ha. of each sulphate.



## 6). Experiment with Hemp.

In this experiment, two different kinds of soils i.e. an alluvial sand and a diluvial loam were applied. Four zinc pots, each having an area of  $1/13750$  ha., were filled with 30 kilo. sandy soil and the other four received 22.5 kilo. loamy soil. Each pot again received 3 g. double superphosphate, 30 g. kainit and 5 g. ammonium nitrate on April 29. Further, 7.5 g. ammonium nitrate was applied as top-dressing in three fractions, i.e. May 27, July 12 and 27. Manganese sulphate was applied at the rate of 66.6 kilo. salt per ha. as top-dressing in two fractions i.e. May 5 and 27.

On April 29, one hundred seeds of hemp were sown in each pot, and the young shoots, later reduced to 45 per pot.

During vegetation, the manganese-plants looked somewhat darker green and more luxuriant. The plants were harvested on July 17, and weighed in the fresh state with the following result, g. :

Average of two parallel pots.

Soil.	Pot.	Stalks.	Roots.	Leaves.	Total.	Comparative yield.	
						Stalks.	Total.
Sandy soil	Control ... ..	336.7	56.9	219.0	612.6	100	100
	MnSO <sub>4</sub> ... ..	380.1	59.2	234.8	674.1	113	110
Loamy soil	Control ... ..	258.3	39.7	149.3	447.3	100	100
	MnSO <sub>4</sub> ... ..	297.4	43.1	164.3	504.8	115	113

This result shows that hemp is moderately stimulated by manganese sulphate on sandy as well as on loamy soil.

## 7). Experiment with Beans.

On October 25, twelve zinc pots, each having an area of  $1/200000$  ha. received 10 kilo. air-dry soil, an alluvial sand, and four days later they were manured with 1.19 g. ammonium sulphate, 3.64 g. common superphosphate

and 10.24 g. kainit. They received again manganese sulphate at the rates of 20 and 200 kilo. salt per ha. in two different application, i.e. together with the manure and as top-dressing in five fractions (March 9, 22, April 6, 14 and 21) as follows :

Pots I	with manure only	} together with manure, } in five fractions.
„ II	0.1 g. manganese sulphate	
„ III	1.0 g. „ „	
„ IV	0.1 g. „ „	
„ V	1.0 g. „ „	

The pots were prepared in duplicate, while for the series I four parallel pots were prepared. On Oct. 31, two seeds of beans previously steeped in water were sown per pot.

In the beginning, the plants of the pots II and III looked more vigorous than those of the others, while towards the end of vegetation those of the pots III and IV seemed most luxuriant. The plants were harvested on June 27. The average weight in the air-dry state was as follows, g. :

Pots.	MnSO <sub>4</sub>	Grains.	Straw and Chaffs.	Total.	Comparative yield.	
					Grains.	Total.
I	Control ... ..	19.3	22.4	41.7	100	100
II	0.1 g. MnSO <sub>4</sub> together with manure	29.2	25.8	55.0	151	132
III	1.0 g. „ „ „ „	31.9	25.9	57.8	165	138
IV	0.1 g. „ in five fractions ...	30.4	30.3	60.7	158	146
V	1.0 g. „ „ „ „ „	26.6	24.6	51.2	128	123

This result shows that :

- 1). Manganese sulphate favors considerably the growth of beans, especially increasing the yield of grains.
- 2). Top-dressing at the *small* rate of 20 kilo. per ha. was more powerful than the application with the general manure (compare IV with II).
- 3). Top-dressing at the very *high* rate had less effect than the same dose with the general manure. Also here the more powerful effect of an excessive dose is noticed in the form of top-dressing.

8). Experiment with Sesamum under Acidic and Alkaline Manure.

On June 26, each zinc pot having an area of 1/137500 ha. received 15 kilo. air-dry soil from unmanured plot of our experimental field (a diluvial loam). Pot A<sub>1</sub>-A<sub>5</sub> were manured with alkaline manure, i.e. 150 c.c. rotten urine and 15 g. bone dust. They received the following amounts of manganese sulphate :

Pot: A <sub>1</sub>	With alkaline manure only.
.. A <sub>2</sub>	0.3 g. Manganese sulphate corresponding to 41.25 kilo. salt per ha.
.. A <sub>3</sub>	0.75 g. " " " " " 103.125 " " " "
.. A <sub>4</sub>	1.5 g. " " " " " 206.25 " " " "
.. A <sub>5</sub>	3.0 g. " " " " " 412.50 " " " "

At the same time, pot B<sub>1</sub>-B<sub>4</sub> received 7.5 g. double superphosphate, 15 g. each of kainit and sodium nitrate, and the following doses of manganese sulphate :

Pot B <sub>1</sub>	With acidic manure only.
.. B <sub>2</sub>	0.3 g. salt dissolved in 1 litre and applied together with manure,
.. B <sub>3</sub>	0.3 g. " in two fractions, i.e. July 20 and 28,
.. B <sub>4</sub>	0.6 g. " in four " i.e. July 20, 28, Aug. 5 and 19.

On June 28, twenty seeds were sown per pot, and the young shoots reduced to 5 per pot of about equal size. On Aug. 5 between the pots A<sub>1</sub>-A<sub>5</sub> no decisive difference could be observed, while in the case of pots B<sub>1</sub>-B<sub>4</sub> the manganese plants seemed more luxuriant.

The plants were harvested on Sept. 22, and weighed in the air-dry state with the following result, g. :

1). Alkaline Manure :

Pots.	MnSO <sub>4</sub>	Full grains.	Empty grains.	Stalks and husks.	Total.	Comparative yield of full grains.
A <sub>1</sub>	Control ... ..	15.35	0.50	37.75	53.60	100
A <sub>2</sub>	0.3 g. MnSO <sub>4</sub> ... ..	15.00	0.60	37.90	53.50	98
A <sub>3</sub>	0.75 g. " ... ..	15.00	0.30	36.50	51.80	98
A <sub>4</sub>	1.5 g. " ... ..	15.80	0.40	39.60	55.80	103
A <sub>5</sub>	3.0 g. " ... ..	15.35	0.35	36.05	51.75	100

II). Acidic Manure :

Pots.	MnSO <sub>4</sub>	Full grains.	Empty grains.	Stalks and husks.	Total.	Comparative yield of full grains.
B <sub>1</sub>	Control ... ..	20.30	0.30	48 20	68 80	100
B <sub>2</sub>	0.3 g. salt with manure...	22.25	0.50	54.65	77.40	110
B <sub>3</sub>	0.3 g. ,, in 2 fractions...	22.30	0.50	50.50	71.30	110
B <sub>4</sub>	0.6 g. ,, " 4 " ...	22.60	0.30	51.90	74.80	111

From this result, we learn that,

- 1). The stimulating action of manganese is greatly influenced by the reaction of the manure applied. Acidic manure seems to be favorable to the action of manganese, while alkaline manure interferes with the effect of manganese, which may perhaps be due to the precipitation of manganese by the alkaline manure.
- 2). Under favorable manuring conditions manganese can be safely applied together with the manure (compare B<sub>2</sub> with B<sub>3</sub> and B<sub>4</sub>), although as top-dressing it will be preferable in many cases.

g). Experiment with Spinach under Acidic and Alkaline Manure.

Eighteen zinc pots, each having an area of 1/200000 ha., were filled with 16 kilo. air-dry soil from an unmanured plot of our experimental field (a diluvial loam). To five pots, alkaline manure was applied, and to the other four acidic manure as follows :

- |                                   |   |   |
|-----------------------------------|---|---|
| I. Alkaline manure<br>(5 pots)    | { | 100 c.c. rotten urine,<br>10 g. steamed bone dust.                    |
| II. Acidic manure ...<br>(8 pots) | { | 5 g. double superphosphate,<br>10 g. kainit,<br>10 g. sodium nitrate. |

The manure was carefully mixed with the soil on July 23, and only the putrid urine was simultaneously applied with manganous sulphate on Aug. 13. The relations were as follows :

Manganese sulphate per pot.

- 0
- I. Alkaline manure { 0.2 g. together with the manure,  
0.5 g. " " " "  
1.0 g. " " " "  
2.0 g. " " " "
- 0
- II. Acidic manure { 0.2 g. as top-dressing in 2 fractions,  
0.3 g. " " " 3 "  
0.2 g. together with the manure.

On Aug. 15, twenty seeds were sown per pot, and the young shoots reduced to six per pot of about equal size. Manganous sulphate in fractional doses were applied I Sept. 15, II Oct. 7, and III Oct. 15. On Oct. 7, some difference in growth could be noticed, the manganese plants showing more luxuriance.

The plants were harvested Oct. 28, and weighed in the fresh state with the following result, g. :

I). Alkaline manure :

Pots.	Manganous sulphate.			Yield per pot.	Comparative yield.
	Per pot g.	Per ha. kilo.	Mode of application.		
I	0	0	0	23.3	100
II	0.2	40	together with the manure	23.7	102
III	0.5	100	" " " "	29.4	126
IV	1.0	200	" " " "	30.9	133
V	2.0	400	" " " "	27.1	116

It will be noticed that the maximum yield was obtained by the application of manganese sulphate in the rate of 200 kilo. per ha. in presence of a manure of alkaline nature. The ratio of 400 kilo. per ha. led already to some depression.

II). Acidic manure :

Pots.	Manganous sulphate.			Yield per pot.	Comparative yield.
	Per pot g.	Per ha. kilo.	Mode of application.		
I	0	0	0	57.1	100
II	0.2	40	As top-dressing in a fractions	73.8	129
III	0.3	60	" " " " 3 "	74.3	130
IV	0.2	40	together with the manure	60.3	106

This result shows that fractional top-dressing led to a better yield than the simultaneous application of manganese with the manure. It will be also seen that the ratio of 40 kilo. manganese sulphate per ha. had a greater relative effect with the acidic than with the alkaline manure. It appears then, that alkaline manure renders the manganese sooner un-available than the acidic manure which may be easily understood, since the manganese sulphate is transformed sooner into insoluble manganese compounds.

10). Experiment with Paddy-rice.

Two different soils, a diluvial loamy soil rich in humus and an alluvial sandy soil poor in humus served for this test. Thirty two zinc pots (area=1/200,000 ha.) were filled each with 17.63 kilo. loamy soil, while another set of thirty two pots received 21.38 kilo. of the sandy soil. Manganese sulphate was here tested at the rate of 30 kilo. per ha. with four manurial mixtures, hence sixteen groups of pots were prepared, each consisting of four pots. The manurial mixtures were as follows :

Manures	A	B	C	D
Ammonium sulphate ... ..	12 g.	ditto.	ditto.	ditto.
Double superphosphate ... ..	5 g.	ditto.	—	—
Di-sodium phosphate ... ..	—	—	102 g.	ditto.
Potassium sulphate ... ..	10 g.	—	10 g.	—
Potassium carbonate ... ..	—	793 g.	—	793 g.
Sodium sulphate... ..	92 g.	ditto.	—	—
Limestone ... ..	—	—	125 g.	ditto.

In each of the above four mixtures, the amounts of phosphoric acid and of potassa respectively were equal, i.e. 2.02g.  $P_2O_5$  and 5.41 g.  $K_2O$ . Since the superphosphate in the pots A and B provides the soil with a small dose of lime i.e. 0.7 g. CaO, the corresponding amount of lime was added to the pots C and D in the form of pulverized limestone <0.5 m.m. Since, on the other hand, the sodium phosphate in the pots C and D provides the soil with 1.77 g.  $Na_2O$ , the corresponding amount of soda was added to the pots A and B in the form of sodium sulphate. Of these four mixtures, A was decidedly acidic, D decidedly alkaline, while B and C were probably neutral or nearly so.

All the manurial compounds were applied June 10, 1906, with the exception of potassium carbonate which was applied a week later, while manganese sulphate was applied still five days later.

On June 22, each pot received eight individuals of young paddy rice plants of about equal size (20 cm.) in a bundle.

During vegetation, the plants of the pots with manganese sulphate looked more vigorous than those of the check pots, although the development of the plants differed greatly on the other hand from the nature of manures applied. The following table shows the height of plants and numbers of stalks and ears at three different periods :

Average of four parallel pots.

Soils.	Pots.	Nature of manures and MnSO <sub>4</sub>	July 18		August 9		November 1		
			Height cm.	No. of stalks.	Height cm.	No. of stalks.	Height cm.	No. of ears.	
Sandy soil	A	Acidic ... ..	56.7	24	92.7	66	113.0	61	
	A'	„ +MnSO <sub>4</sub> ...	58.8	24	94.5	64	114.8	66	
	B	Neutral ... ..	58.8	21	97.9	57	114.8	56	
	B'	„ +MnSO <sub>4</sub> ...	59.1	21	94.2	63	115.2	66	
	C	„ ... ..	59.7	23	98.2	65	113.0	57	
	C'	„ +MnSO <sub>4</sub> ...	60.3	27	93.2	69	118.2	63	
	D	Alkaline ... ..	59.7	24	91.8	65	119.4	60	
	D'	„ +MnSO <sub>4</sub> ...	63.0	28	92.4	64	118.5	64	
	Loamy soil	A	Acidic ... ..	56.7	16	89.4	51	112.4	79
		A'	„ +MnSO <sub>4</sub> ...	53.0	21	94.5	61	112.1	82
B		Neutral ... ..	60.0	18	95.5	55	113.0	81	
B'		„ +MnSO <sub>4</sub> ...	60.3	22	95.2	60	116.4	80	
C		„ ... ..	56.1	20	89.7	56	112.1	84	
C'		„ +MnSO <sub>4</sub> ...	57.0	22	94.2	65	116.1	79	
D		Alkaline ... ..	58.8	20	91.2	57	115.8	83	
D'		„ +MnSO <sub>4</sub> ...	63.0	23	91.5	57	115.8	86	

The adjoining plate XXII shows the development, Oct. 25.

The plants were harvested Nov. 1, and weighed in the air-dry state with the following result, g. :

Average of four parallel pots.

Soils.	Pots.	Nature of manures and MnSO <sub>4</sub>	Grains.	Straw.	Chaffs.	Total.
Sandy soil	A	Acidic ... ..	80.73	111.88	3.35	195.96
	A'	„ +MnSO <sub>4</sub> ...	85.78	118.40	3.25	207.43
	B	Neutral ... ..	83.90	113.10	2.68	199.68
	B'	„ +MnSO <sub>4</sub> ...	92.05	124.41	3.08	219.54
	C	Neutral ... ..	83.20	113.23	2.58	199.01
	C'	„ +MnSO <sub>4</sub> ...	91.52	121.25	2.90	215.67
	D	Alkaline ... ..	90.90	117.05	3.48	211.43
	D'	„ +MnSO <sub>4</sub> ...	97.45	121.93	4.33	223.71
	A	Acidic ... ..	63.77	137.93	5.27	206.97
	A'	„ +MnSO <sub>4</sub> ...	66.70	140.90	3.93	211.53
Loamy soil	B	Neutral ... ..	75.33	135.55	4.90	215.78
	B'	„ +MnSO <sub>4</sub> ...	85.88	136.90	4.40	227.21
	C	Neutral ... ..	85.60	130.57	4.23	220.40
	C'	„ +MnSO <sub>4</sub> ...	97.50	139.23	3.88	240.61
	D	Alkaline ... ..	85.73	132.17	3.77	222.67
	D'	„ +MnSO <sub>4</sub> ..	63.10	136.20	4.20	233.50

If we now assume the yield of grains of the pots without manganese sulphate in each manurial mixture of each soil respectively to be = 100, we obtain the following ratio :



Soils.	Pots.	Nature of manures and MnSO <sub>4</sub>	Comparative yield of grain.
Sandy-soil.	A	Acidic ... ..	100
	A'	„ +MnSO <sub>4</sub> ... ..	106
	B	Neutral ... ..	100
	B'	„ +MnSO <sub>4</sub> ... ..	110
	C	Neutral ... ..	100
	C'	„ +MnSO <sub>4</sub> ... ..	110
	D	Alkaline ... ..	100
	D'	„ +MnSO <sub>4</sub> ... ..	107
Loamy-soil.	A	Acidic ... ..	100
	A'	„ +MnSO <sub>4</sub> ... ..	105
	B	Neutral ... ..	100
	B'	„ +MnSO <sub>4</sub> ... ..	114
	C	Neutral ... ..	100
	C'	„ +MnSO <sub>4</sub> ... ..	114
	D	Alkaline ... ..	100
	D'	„ +MnSO <sub>4</sub> ... ..	109

From this result, it can be inferred that

- 1.) The stimulating effect of manganese salt differs to some extent according to the nature of soils. The maximum increase caused by manganese salt amounted to 10 % on sandy soil, while that with the loamy soil reached 14 %.
- 2.) The stimulating effect of manganese salt also depends upon the nature of the manuring mixture. The maximum yield was observed with the neutral manuring mixtures in each case of soils (B' and C').

B. STIMULATING ACTION OF IODINE.<sup>1)</sup>1). Experiment with *Panicum miliaceum*.

This experiment was carried out with tall zinc bottomless cylinders inserted in the ground. Twelve cylinders, each having an area of 1/200000 ha., were filled with 18.75 kilo. air-dry alluvial sand.

The potassium iodide was applied as follows :

	Per pot, g.	Ratio per ha., g.
I. ... ..	Control	0
II ... ..	0.000047	9.4
III ... ..	0.000094	18.8
IV ... ..	0.00047	94.0
V ... ..	0.00094	188.0
VI ... ..	0.00188	376.0

Each cylinder received June 20 secondary sodium phosphate, potassium sulphate and ammonium sulphate at the rate of 56.3 kilo.  $P_2O_5$  and 75 kilo. each of N and  $K_2O$  per ha. Three days later, the seeds were sown, and the young shoots later reduced per pot to four of about equal size. Potassium iodide was applied as top-dressing in three fractions, i.e. July 13, 26, and Aug. 3. During vegetation, the treated plants looked more vigorous than the control plants. The plants were harvested on Sept. 5, and weighed in the air-dry state with the following result, g. :

## Average of two parallel cylinders.

Pots.	KI per ha., g.	Grains.	Straw.	Chaffs.	Total.	Comparative yield.	
						Grains.	Total.
I	-	22.9	30.7	3.2	56.8	100	100
II	9.4	23.4	32.9	3.7	60.0	102	106
III	18.8	24.0	36.8	4.0	64.8	105	114
IV	94.0	24.5	38.8	3.8	67.1	107	118
V	188.0	26.8	31.0	4.1	61.9	117	123
VI	376.0	27.7	41.0	4.2	72.9	121	128

1). For the stimulating action of potassium iodide upon sesamum and barley see Bulletin of the Imperial Central Agr. Exper. Stat. Japan, Vol. I, No. I, p. 35.

This result shows that small doses of potassium iodide act favorably on the yield of *Panicum miliaccum*, and that the dose of potassium iodide can be still profitably increased to 376 g. per ha.

2). Experiment with Barley.

This experiment was carried out with tall zinc bottomless cylinders inserted in the ground. Each cylinder having an area of 1/95500 ha. was filled with 26.67 kilo. dry soil, a diluvial loam. Potassium iodide was applied at the rate of

I	...	...	...	...	...	...	...	...	...	0	}	per ha.
II	...	...	...	...	...	...	...	...	...	25 g.		
III	...	...	...	...	...	...	...	...	...	50 "		
IV	...	...	...	...	...	...	...	...	...	100 "		
V	...	...	...	...	...	...	...	...	...	500 "		
VI	...	...	...	...	...	...	...	...	...	1 kilo.		
VII	...	...	...	...	...	...	...	...	...	5 "		

For each series, ten cylinders were prepared. On Nov. 2, each cylinder received 17.58 g. blood meal, 8.43 g. common superphosphate and 21.5 g. kainit; and again received 30 seeds of six sided barley. The young shoots were later reduced to 20 per pot of about equal size. Dilute solution of potassium iodide was applied as top-dressing in three fractions, i.e. March 19, April 17 and May 1. During vegetation, the plants supplied with potassium iodide looked more vigorous than those of the control cylinders. The following table shows the data regarding the growth observed May 24:

Average of ten parallel cylinders.

Cylinders.	Kl p t ha.	Height cm.	No. of stalks.
I	-	27	41
II	25 g.	-	41
III	50 "	38	42
IV	100 "	42	41
V	500 "	48	48
VI	1 kilo.	49	44
VII	5 "	46	43

The plants were harvested June 8, and weighed in the air-dry state with the following result, g. :

Average of ten parallel cylinders.

Cylinders	KI per ha.	Grains.	Straw.	Chiffs.	Total.	Comparative yield.	
						Grains.	Total.
I	0	65.8	84.0	5.2	155.0	100	100
II	25 g.	69.8	88.9	6.1	164.8	105	106
III	50 "	74.2	96.5	6.8	177.5	113	115
IV	100 "	77.1	97.3	7.2	181.6	116	117
V	500 "	87.9	112.0	7.7	207.6	134	134
VI	1 kilo.	81.3	101.1	6.7	189.1	124	122
VII	5 "	76.6	95.5	6.9	179.0	116	115

This result shows that potassium iodide acts very favorably on the yield of barley, the optimum dose being 500 g. per ha.

### C. STIMULATING ACTION OF FLUORINE.

#### 1). Experiment with *Panicum Miliaceum*.

This experiment was carried out with tall zinc bottomless cylinders inserted in the ground. Twelve cylinders, each having an area of 1/200000 ha., were filled with 18.75 kilo. air-dry soil, an alluvial sand. Sodium fluoride was applied as follows :

	Per pot, g.	Per ha., g
I ... ..	Control	
II ... ..	0.000188	37.6
III ... ..	0.00094	188.0
IV ... ..	0.00141	282.0
V ... ..	0.00188	376.0
VI ... ..	0.0047	940.0

Each cylinders received June 20 secondary sodium phosphate, ammonium sulphate and potassium sulphate at the rate of 56.3 kilo. phosphoric acid and 75 kilo. each of nitrogen and potassa per ha. Three days later, the seeds were sown, and the young shoots afterwards reduced to four per

pot. Sodium fluoride was applied as top-dressing in three fractions, i.e. July 13, 26, and Aug. 3. During vegetation, the treated plants looked more vigorous than the control plants. The plants were harvested Sept. 5, and weighed in the air-dry state with the following result, g. :

Average of two parallel cylinders.

Pots.	NaF per ha. g.	Grains.	Straw.	Chaffs.	Total.	Comparative yield.	
						Grains.	Total.
I	0	22.9	30.7	3.2	56.8	100	100
II	37.6	24.3	36.7	4.0	65.0	106	114
III	188.0	24.5	38.4	3.3	66.2	107	117
IV	282.0	27.5	39.0	3.5	70.0	120	123
V	376.0	29.9	41.2	5.1	76.2	131	134
VI	940.0	31.7	42.5	5.2	79.4	138	140

This result shows that sodium fluoride acted powerfully on the yield of *Panicum miliacum*, and that the dose of that salt at the rate of 940 g. per ha. brought the maximum harvest.

2). Experiment with Barley.

This experiment was carried out with tall zinc bottomless cylinders inserted in the ground. Each cylinder having an area of 1/137500 ha. was filled with 15.56 kilo. dry soil, a diluvial loam. Sodium fluoride was applied at the rate of

I	...	...	...	...	...	0
II	...	...	...	...	...	250
III	...	...	...	...	...	500
IV	...	...	...	...	...	1000
V	...	...	...	...	...	5000

g. per ha.

For each series, ten cylinders were prepared. On Nov. 2, each cylinder received 12.15 g. blood meal, 5.86 g. common superphosphate and 15 g. kainit, and 25 seeds of six side barley. The young plants were afterwards reduced to 15 per pot. Sodium fluoride was applied as top-dressing in three fractions, i.e. March 19, April 17, and May 1.

The plants supplied with sodium fluoride developed better than those of

the control cylinders. The following table shows the data regarding the growth observed at May 24 :

Average of ten parallel cylinders.

Cylinders.	NaF per ha. g.	Height cm.	No. of stalks.
I	0	93.9	42
II	250	97.0	44
III	500	97.3	42
IV	1000	96.4	43
V	5000	97.3	45

The plants were harvested on June 5, and weighed in the air-dry state with the following result, g. :

Average of ten parallel cylinders.

Cylinders	NaF per ha.	Grains.	Straw.	Chaffs.	Total.	Comparative yield.	
						Grains.	Total.
I	0	63.5	78.6	4.5	147.5	100	100
II	250 g.	68.8	83.3	5.6	157.7	108	107
III	500 "	70.6	84.5	5.8	160.9	111	109
IV	1000 "	71.0	86.1	6.0	163.1	112	111
V	5000 "	74.9	92.8	6.3	174.0	118	118

This result shows that sodium fluoride acted favorably on the yield of barley even at a relatively high dose of 5 kilo. per ha.

#### D. SUMMARY OF RESULTS.

From the results of our experiments here described, we can draw the following conclusions :

- 1). Manganese as well as iron stimulates the development of plants. Different plants differ considerably in their susceptibility toward the action of manganese and iron salt. In some cases, the joint application of manganese and iron salt exerts a better effect on the development of plants than when each of these salts is applied alone, while in other cases the opposite results were observed. Generally manganous sulphate was better than ferrous sulphate.

- 2). The stimulating action of manganese differs greatly with the character of soil.
- 3). The stimulating action of manganese differs also considerably with the mode of its application. When applied as top-dressing, it gives in general better results than when applied together with the manure.
- 4). The stimulating action of manganese differs again greatly with the nature of the manurial mixture. A manurial mixture of a nearly neutral reaction, exerts the best effect. Manures of decisive alkaline or acidic nature on the other hand are not so favorable, since the former interferes with the effect of the manganese salt, while the latter are not suitable for the growth of most plants.
- 5). The amounts of manganese salt to be applied will in general be sufficient at the rate of 20-50 kilo. of the crystallized sulphate per ha.
- 6). The following table shows conveniently the stimulating effects of manganese and iron salts under different conditions :

I.) Field Experiments (diluvial loam).

Crop.	Area of each plot.	Nature of manurial mixture.	Stimulating Compound.		Percentage increase of Harvest.
			Amount per ha.	Mode of application.	
Barley ... ..	1,100 ha.	Alkaline	33.2 kilo. $Mn_2O_4$	top-dressing in 4 portions	6% grains
Wheat ... ..	"	"	" "	" " " " "	9% "
Upland-Rice ...	1,300 ha.	"	15 kilo. $MnSO_4 + 4aq.$ " $FeSO_4 + 7aq.$	" " " 3 "	6% "
Buckwheat ...	331 89- meters	"	20 kilo. $MnSO_4 + 4aq.$	together with manure	10% "
			" "	top-dressing in 2 portions	17% "
Beans ... ..	1,278 ha.	"	" "	together with manure	26% "
			" "	top-dressing in 3 portions	44% "
Sweet-Potato ...	1,120 ha.	"	15 kilo. " " $FeSO_4 + 7aq.$	" " " " "	35% tubers

Crop.	Area of each plot.	Nature of natural mixture.	Stimulating Compound.		Percentage increase of Harvest.
			Amount per ha.	Mode of application.	
Sweet-Potato ...	1,100 ha.	Alkaline	15 kilo. $\text{FeSO}_4 + 7\text{aq.}$	top-dressing in 3 portions	21% tubers
			" $\text{MnSO}_4 + 4\text{aq.}$	" " " " "	34% "
Radish ...	1,200 ha.	"	20 kilo. "	" " " " "	21% roots
" ...	1,278 ha.	"	" "	together with manure	4% grains
" ...	"	"	" "	top-dressing in 3 portions	8% "
" ...	17.5 sq. meters	"	" $\text{FeSO}_4 + 7\text{aq.}$	" " " " "	26% roots
			" "	" " " " "	29% "
			" "	" " " " "	35% "
			" $\text{FeSO}_4 + 7\text{aq.}$	" " " " "	2% "
Carrot ...	1,400 ha.	"	" "	" " " " "	20% "
			" $\text{MnSO}_4 + 4\text{aq.}$	" " " " "	20% "
<i>Brassica Campes- tris</i> , var. <i>Mikawa- Hakui</i> ...	"	"	" "	together with manure	8% total
			" "	top-dressing in 2 portions	14% "
			" $\text{FeSO}_4 + 7\text{aq.}$	" " " " "	15% "
" "	1,750 ha.	"	" "	" " " " "	18% "
			" $\text{MnSO}_4 + 4\text{aq.}$	" " " " "	27% "
<i>Brassica Campes- tris</i> , var. <i>Mikawa- Hakui</i> ...	1,278 ha.	"	" "	together with manure	10% "
"	"	"	" "	top-dressing in 3 portions	23% "
Egg-plant ...	1,200 ha.	Acidic	10 kilo. $\text{Mn}_2\text{O}_4$	" " " " "	11% fruits
Alsic Clover ...	4.05 sq. meters	Neutral	25 kilo. $\text{Mn}_2\text{O}_4$	" " " " "	20% total
Red Climbing ...	"	Alkaline	" "	" " " " "	20% "



Crop.	Area of each pot.	Nature of manurial mixture.	Stimulating Compound.		Percentage increase of Harvest.
			Amount per ha.	Mode of application.	
Meadow Soft-grass	4.06 sq. meters	Alkaline	25 kilo. $Mn_2O_4$	top-dressing in 3 portions	35% total
Tea plant (old)...	1/375 ha.	"	37.5 kilo. "	" " " " "	29% leaves
Young Tea-plant (after second year)	1/2,250 ha.	"	20.3 kilo. $MnSO_4 + 4aq$	" " " 5 "	15% total
Young Tea-plant (after second year)	"	Neutral	12.19 kilo. "	" " " 3 "	18% "

II). Pot Experiments :

Crop.	Area of each pot.	Soil.	Nature of manurial mixture.	Stimulating Compound.		Percentage increase of Harvest.
				Amount per ha.	Mode of application.	
Paddy-Rice	1,200,000 ha.	Alluvial sand	Acidic	30 kilo. $MnSO_4 + 4aq.$	together with mixture	6% grains
			Neutral	" "	" " "	10% "
			"	" "	" " "	10% "
			Alkaline	" "	" " "	7% "
		Diluvial loam	Acidic	" "	" " "	5% "
			Neutral	" "	" " "	14% "
			"	" "	" " "	14% "
			Alkaline	" "	" " "	19% "
Earley	1/65,500 ha.	"		10 kilo. $Mn_2O_4$	top-dressing in 3 portions	14% "
				25 kilo. "	" " " " "	18% "
			Acidic	50 kilo. "	" " " " "	12% "
				100 kilo. "	" " " " "	10% "
				500 kilo. "	" " " " "	2% "
Buckwheat	1/18,100 ha.	"	Neutral	20 kilo. $Mn_2O_4 + 4aq.$	" " " 2 "	9% "

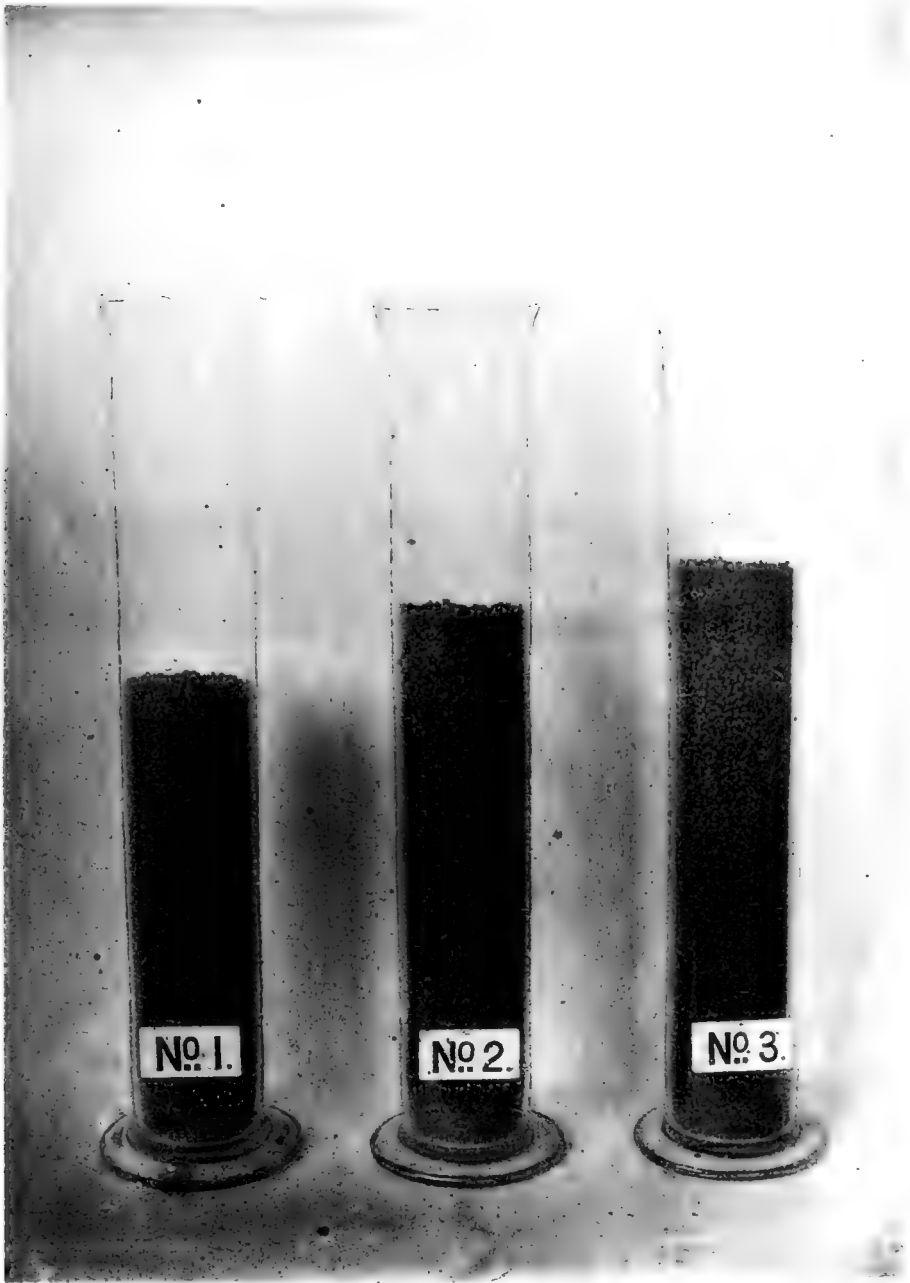
Crop.	Area of each pot.	Soil.	Nature of manurial mixture.	Stimulating Compound.		Percentage increase of Harvest.
				Amount per ha.	Mode of application.	
Beans.	1,200,000 ha.	Alluvial sand	Acidic	20 kilo. $MnSO_4 + 4aq.$	together with manure	51% grains
				200 kilo. "	" " "	65% "
				20 kilo. "	top-dressing in 5 portions	58% "
				200 kilo. "	" " " " "	28% "
Sesamum	1,137,500 ha.	Diluvial loam	Alkaline	41.25 kilo. "	together with manure	-2% "
				103.125 kilo. "	" " "	-2% "
				206.25 kilo. "	" " "	3% "
				412.5 kilo. "	" " "	±
"	1,137,500 ha.	"	Acidic	41.25 kilo. $MnSO_4 + 4aq.$	" " "	10% "
				" "	top-dressing in 2 portions	10% "
				82.5 kilo. "	" " " 4 "	11% "
<i>Panicum millicerum</i>	1,200,000 ha.	Alluvial sand.	Neutral	9.4 kilo. $MnSO_4 + 4aq.$	} " " " 3 "	9% "
				" $Fe_2O_3 + 7aq.$		
				18.5 kilo. $MnSO_4 + 4aq.$		
				" $Fe_2O_3 + 7aq.$		
				28.2 kilo. $MnSO_4 + 4aq.$	} " " " " "	19% "
				" $Fe_2O_3 + 7aq.$		
				37.6 kilo. $MnSO_4 + 4aq.$	} " " " " "	17% "
" $Fe_2O_3 + 7aq.$						
75.2 kilo. $MnSO_4 + 4aq.$	} " " " " "	11% "				
" $Fe_2O_3 + 7aq.$						
188 kilo. $MnSO_4 + 4aq.$	} " " " " "	2% "				
" $Fe_2O_3 + 4aq.$						
Spinach	"	Diluvial loam	Alkaline	45 kilo. $MnSO_4 + 4aq.$	together with manure	2% total
				100 kilo. "	" " "	20% "
				200 kilo. "	" " "	33% "
				40 kilo. "	" " "	10% "

Crop.	Area of each pot.	Soil.	Nature of manurial mixture.	Stimulating Compound.		Percentage increase of Harvest.
				Amount per ha.	Mode of application	
Spinach ...	1/200,000 ha.	Diluvial loam	Acidic	40 kilo.	top-dressing in 2 portions	29% total
				60 kilo.	" " " 3 "	30% "
				40 kilo.	together with manure	6% "
Radish ...	1/18 180 ha.	"	Neutral	30 kilo.	top-dressing in 3 portions	15% roots
Hemp ...	1/13.750 ha.	Alluvial sand	Acidic	66.6 kilo.	" " " 2 "	13% stalk
		Diluvial loam	" "	" "	" " " " "	15% "
<i>Polygonum tinctorium</i>	1/18 180 ha.	"	Neutral	15 kilo.	" " " 3 "	13% leaves

7). Different plants differ considerably in their susceptibility toward the stimulating effect of potassium iodide and sodium fluoride. In most cases, 25-500 g. potassium iodide per ha. or 100-1000 g. sodium fluoride per ha. will be proper doses.

Some experiments with manganese, iodine and fluorine compounds will be continued with modification





Control.

$MnSO_4$   
together with the Manure.

$MnSO_4$   
as top-dressing.

To page 41.





No manure.

Manure.

Manure +  $MnSO_4$

Fig. page 45



No manure.

Manure.

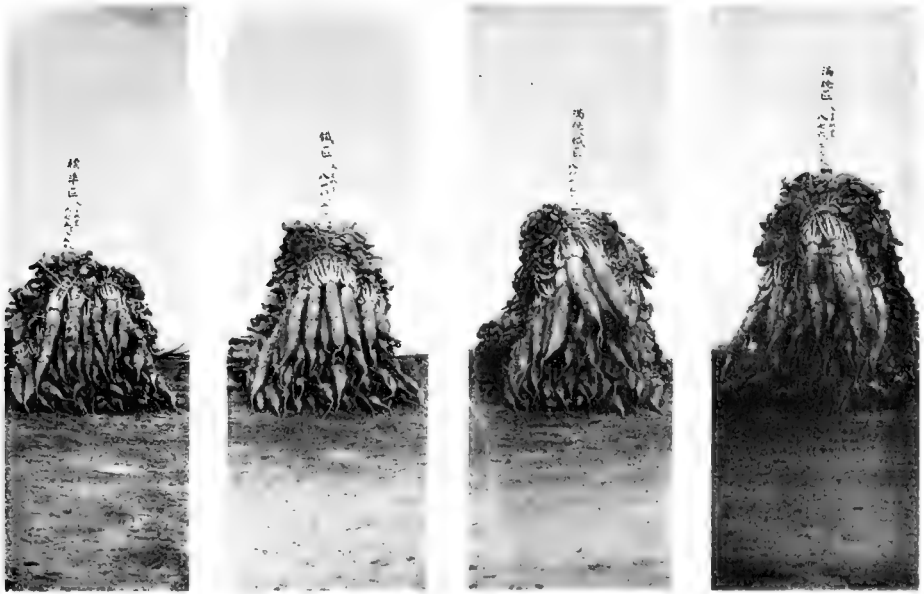
Manure +  $MnSO_4$ .

Fig. page 46.





(1)



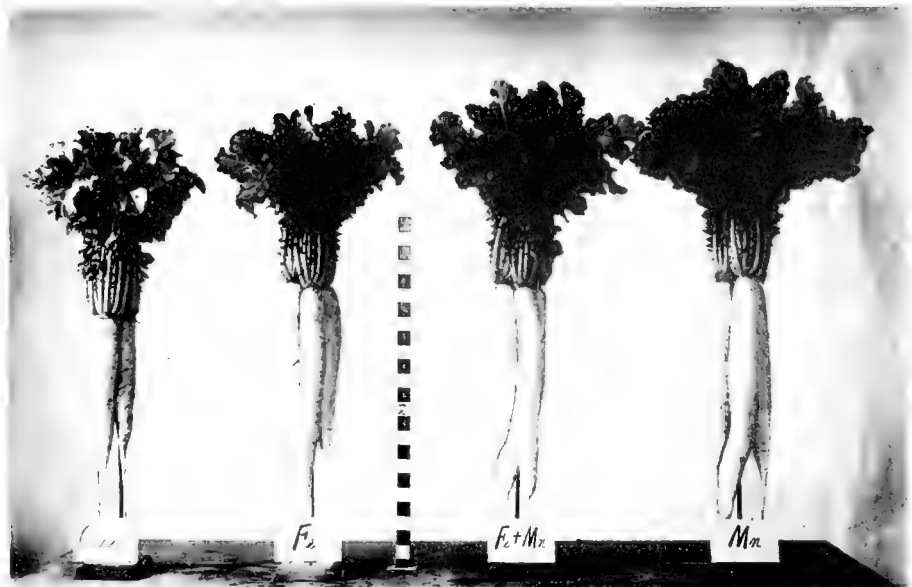
Control.

Fe.

Fe + Mn.

Mn.

(2)



Control.

Fe.

Fe + Mn.

Mn.

To page 51.





To page 68

A	A'	B	B'	C	C'	D	D'
Acidic manure.	ditto.	Neutral manure.	ditto.	Neutral manure.	ditto.	Alkaline manure.	ditto.
	+ Mn SO <sub>4</sub> .		+ Mn SO <sub>4</sub> .		+ Mn SO <sub>4</sub> .		+ Mn SO <sub>4</sub> .
Sandy soil.							



To page 68.

A	A'	B	B'	C	C'	D	D'
Acid manure.	ditto.	Neutral manure.	ditto.	Neutral manure.	ditto.	Alkaline manure.	ditto.
	+ Mn SO <sub>4</sub> .		+ Mn SO <sub>4</sub> .		+ Mn SO <sub>4</sub> .		+ Mn SO <sub>4</sub> .
Loamy Soil.							



## On Manuring with Magnesium Sulphate.

BY

G. DAIKUHARA.

Manuring with magnesium compounds will be necessary in all such cases where lime exceeds to any great extent the amount of magnesia in soils, and the application of magnesia must be more heavy in cases where cereals are to be grown than for leguminous crops, buckwheat, cruciferous plants, &c. The simplest method would seem to be to add finely powdered magnesit to the soil. But since this material is found only in a few countries in large deposits and is very difficult to pulverize to the necessary degree of fineness, and further, since artificial magnesium carbonate and burnt magnesia are rather too expensive, there remains as the only thing suitable, magnesium compound, the crystallized sulphate of commerce. Of this salt much less would be required than of magnesit as we have formerly pointed out. Our experiments with barley and rice in sand culture have shown that 4.8 resp. 9.6 parts of that sulphate are as effective as 100 parts magnesit. In a loamy humus soil from Komaba this ratio was found to be as 14:100,<sup>1)</sup> while in a clay soil rich in zeolites this ratio was 23:100.<sup>2)</sup>

In cases where a heavy manuring with magnesit would be necessary, it would, however, be impractical and too expensive to add the calculated big dose of magnesium sulphate to the whole soil, because not only the sulphate but also the exceedingly fine precipitates it yields in the soil (phosphate, silicate, humate, carbonate, &c.) would after a few years have passed considerably into the drainage water and would be lost. It is therefore a

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1). Bul. Coll. Agr., Imp. Univ. Tokio, Vol. VII, No. 1, p. 63.

2). See Nakamura's article in this Bulletin Vol. I, No. 1.

much better plan to apply magnesium sulphate only as top dressing, because in this way much smaller quantities are required. This top dressing of course has to be repeated annually. It was however necessary to study the question as to how much magnesium sulphate in form of top dressing would be of the same effect as a given quantity of the salt in the general manure.

The loamy humus soil<sup>1)</sup> of our experimental farm served for this experiment. The soil was mixed with 4 % of air slaked lime containing 67.4 % CaO and 4.4 % MgO, thus the soil was too rich in lime and this would have required for the maximum crop of barley 1.161 g MgO = 2.333 g magnesit.

I have instituted two series of experiments, in one of which the magnesium sulphate was applied before sowing while in the other as top dressing. Seventeen large zinc cylinders put in the soil and containing 45.4 Kg soil served for these experiments. The amount of  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$  applied to each cylinder varied as follows :

### I Series.

(Mixed with the whole soil before sowing).

No. of cylinders.	Amount of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ p. cyl	Ratio of MgO applied, to 1000 pts calculated amount of MgO as magnesit.	Agronomical Equivalent of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ , magnesit taken as 100.
I.	56.3 g	8	2.4
II.	225.0 g	32	9.6
III.	450.0 g	64	18.2

1). This soil contained 0.374 % CaO and 0.412 % MgO in air dry state.

II Series. (Top dressing).<sup>1)</sup>

No. of cylinders.	Amount of MgSO <sub>4</sub> ·7H <sub>2</sub> O p. cyl	Ratio of MgO applied, to 1000 pts calculated amount of MgO as Magnesit.	Agronomical Equivalent of MgSO <sub>4</sub> ·7H <sub>2</sub> O, magnesit taken as 100.
I.	22.5 g	3.2	0.96
II.	37.5 g	5.3	1.60
III.	56.3 g	8.0	2.40
IV.	112.5 g	16.0	4.80

The general manure was :

NaNO <sub>3</sub> ... .. .	17.0 g	} in 3 fractions.
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> ... .. .	13.2 g	
Na <sub>2</sub> HPO <sub>4</sub> ... .. .	20.0 g	
K <sub>2</sub> SO <sub>4</sub> ... .. .	20.0 g	

On Nov. 5, 1905, 92 seeds p. cylinder of barley (*var. Goldenmelon*) were sown and after the young plants had reached a height of about 5-6 cm. they were reduced to 70 of equal size. The development in the following spring may be seen from the photographs taken June 5, 1906, and reproduced on Plate XXIII. The plants were cut June 5, 1906 and weighed in the air dry state with the following results :

I Series.

No. of cylinders.	Amount of MgSO <sub>4</sub> ·7H <sub>2</sub> O p. cyl.	Weight of seeds. g		Weight of straw. g		Total yield. g	
		p. cyl.	Average.	p. cyl.	Average.	p. cyl.	Average.
I.	56.3 g	179.3	196.3	301.5	308.5	480.8	504.8
		213.4		315.4		526.2	
II.	225.0 g	243.7	242.1	328.5	329.8	572.3	571.0
		238.5		331.1		569.6	

1). 1/3 of MgSO<sub>4</sub>·7H<sub>2</sub>O was applied before sowing and remaining 2/3 in two fractional top dressings.

No. of cylinders.	Amount of $MgSO_4 \cdot 7H_2O$ p. pot.	Weight of seeds. g		Weight of straw. g		Total yield. g	
		p. cyl.	Average.	p. cyl.	Average.	p. cyl.	Average.
III.	450.0 g	265.9	230.3	288.4	324.0	554.3	554.3
		194.6		359.6		554.3	
IV.	Control	213.0	203.3	275.3	289.2	488.3	492.4
		208.5		288.8		497.3	
		188.3		303.4		491.6	

## II Series.

No. of cylinders.	Amount of $MgSO_4 \cdot 7H_2O$ p. cyl.	Weight of seeds. g		Weight of straw. g		Total yield. g	
		p. cyl.	Average.	p. cyl.	Average.	p. cyl.	Average.
I.	22.5 g	260.1	222.3	364.5	352.0	624.6	574.3
		184.5		339.4		523.9	
II.	37.5 g	202.2	217.2	304.9	320.1	507.1	537.3
		232.1		335.3		567.4	
III.	56.3 g	182.3	192.6	315.8	319.4	498.0	511.9
		202.9		322.9		525.8	
IV.	112.5 g	138.9	185.7	270.0	286.5	408.9	472.2
		232.5		303.0		535.5	
V.	Control	213.0	203.3	275.3	289.2	488.3	492.4
		208.5		288.8		497.3	
		188.3		303.4		491.6	

The results show that in our soil when crystallized sulphate of magnesia was applied before sowing mixing with the whole soil, the best result was obtained with ratio of 32 parts  $MgO$  as  $MgSO_4 \cdot 7H_2O$  to 1000 parts of the calculated amount of  $MgO$  as magnesit, while with top dressing just 1/10 of



MgO as  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$  was sufficient for the same effect. In other words, ca. 10 parts of the crystallized magnesium sulphate is as effective as 100 parts of pulverized magnesit in the former case while 1 part of that salt has the same effect in the case of top dressing.

A second experiment with barley was carried out on the same soil and with the same cylinders, after overliming it with 5 % air slaked lime. In this case however no comparison with top dressing with  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$  was made. Four weeks afterwards<sup>1)</sup> 413.4 g  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$  were mixed with the whole soil before sowing, thus corresponding to the ratio of

$$\text{MgSO}_4 \cdot 7\text{H}_2\text{O} : \text{magnesit} = 14 : 100$$

The general manure, time of sowing and cutting were the same as in the former experiments.

The following results were obtained :

	Average length of plants.	Number of stalks.	Weight in the air dry state. g		
			Seeds.	Straw.	Total.
Control ... ..	81.8 cm.	162	213.8	239.6	453.4
Overlimed ...	85.2 cm.	167	162.4	271.1	433.5
Overlimed+ $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ ..	88.5 cm.	198	193.9	288.4	482.3

### CONCLUSION.

(1). The cheapest and the most effective magnesium compound for the regulation of the lime factor in a soil very rich in lime is the crystallized sulphate.

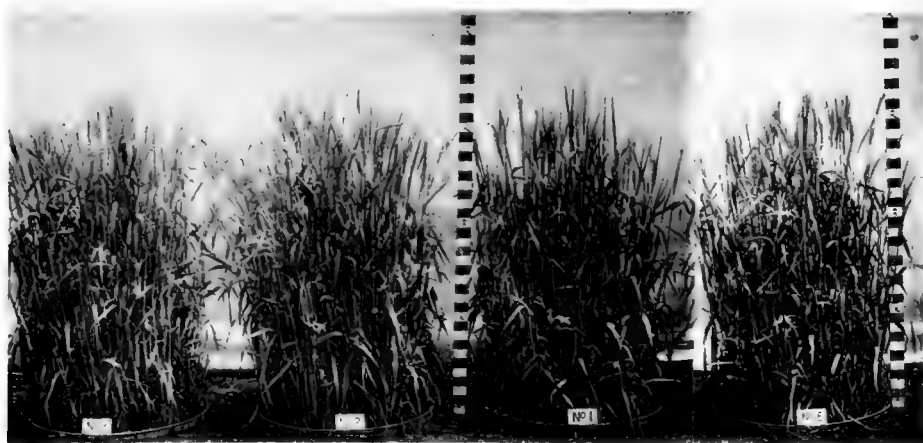
(2). The most effective method of application of the magnesium sulphate is the top dressing, repeated annually in small doses.

1). Attention must be paid to the fact that in such experiments the slaked lime should be transformed completely into carbonate before the magnesium sulphate is added.

(3). The agronomical equivalent on loamy humus soil like ours for  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$  is = 10, i.e. 10 parts of this salt are as effective as 100 parts of the finest powdered magnesit, when applied before sowing mixed with the whole soil, while in the form of top dressing the equivalent would be reduced to 1, i.e. 1 part of that sulphate has under this condition the same effect as 100 parts of magnesit.

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I. Series.



450g.                      225g.                      56.3g.                      control.  
-----  
MgSO<sub>4</sub>.7H<sub>2</sub>O mixed with whole soil.                      overlimed.

II. Series.



112.5g.                      56.3g.                      37.5g.                      22.5g.  
-----  
MgSO<sub>4</sub>.7 H<sub>2</sub>O applied as top dressing.



# On the Influence of Solubility on Availability.

BY

G. DAIKUHARA.

Various former experiments carried out in Komaba and Nishigahara have shown that for several Gramineae the best ratio of lime to magnesia lies between 1/1 and 2/1. With oats the yield was nearly equal in both cases while with upland rice the ratio 1/1 was more favorable than 2/1 and for barley before its flowering period 2/1 was more favorable. With the development of seed, however, relatively more magnesia is required and also in the case of barley the final ratio will be nearer to 1/1 than 2/1. These ratios, however, correspond to equal availability of lime and magnesia, both having been applied as natural carbonates or as nitrates. The ratio of lime to magnesia entering the plant changes, however, very considerably when one of the compounds is insoluble in water while the other is soluble. The latter will then much more readily enter into the plant body than the former.

My former experiment<sup>1)</sup> with rice showed that with artificial carbonate of lime and with magnesia as cryst. sulphate, the best ratio in sand culture was  $\frac{\text{CaO as carbonate}}{\text{MgO as sulphate}} = \frac{30}{1}$ .

I have carried out a similar experiment with barley in sand culture, applying the lime in the form very finely powdered lime stone. Each pot contained 4.5 Kg of dry sand and received the following general manure applied in five fractions :

NaNO <sub>3</sub> ... ..	10 Gr.
K <sub>2</sub> SO <sub>4</sub> ... ..	10 Gr.
KH <sub>2</sub> PO <sub>4</sub> ... ..	1.5 Gr.

While the amount of lime was constant that of magnesia was varied as follows :

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1). This Bulletin Vol. I, No. 1, p. 23-29.

No. of pots.	CaO : MgO	Powdered lime stone.	MgSO <sub>4</sub> +7H <sub>2</sub> O.
I.	5 : 1	80.4 g	54.96 g
II.	10 : 1	" "	27.48 "
III.	20 : 1	" "	13.74 "
IV.	30 : 1	" "	9.16 "
V.	40 : 1	" "	6.87 "
VI.	50 : 1	" "	5.50 "
VII.	60 : 1	" "	4.58 "
VIII.	70 : 1	" "	3.44 "

The seeds of barley (*var. Goldenmelon*) were sown Nov. 10, 1904 and after germination the young plants were reduced to 6 of equal size. The growth in all the pots started equally well but gradually differences appeared, plants in No. I and II were far inferior in growth while the plants in No. VII and VIII were of the most luxuriant development as shown by the following measurements made on Jan. 9, 1905. In the beginning of February the plants in pots No. I died off.

Table I.

No. of Pots.	CaO : MgO.	Average length of the longest leaves.	Average number of stalks p. pot.
I. {	5 : 1	pot 1 9.5 cm.	1
		pot 2 9.0 "	1
II. {	10 : 1	pot 1 10.5 "	1.8
		pot 2 10.5 "	2.2
III. {	20 : 1	pot 1 18.1 "	3.8
		pot 2 18.8 "	3.8
IV. {	30 : 1	pot 1 20.1 "	4.2
		pot 2 20.1 "	4.5
V. {	40 : 1	pot 1 20.6 "	5.0
		pot 2 21.7 "	5.3

No. of Pots.	CaO : MgO.	Average length of the longest leaves.	Average number of stalks p. pot.
VI. {	50 : 1	23.2 cm.	5.9
		23.3 "	5.8
VII. {	60 : 1	23.2 "	6.8
		26.5 "	6.8
VIII. {	80 : 1	24.9 "	6.9
		24.3 "	6.9

The plants were cut on June 10, dried and weighed with the following result, to which are added the observation on the plants in pot No. I; these died in February.

Table II.

No. of pots.	CaO : MgO	Number of stalks.		Number of ears.		Aver. length of stalks	
		p. pot.	Average.	p. pot.	Average.	of each pot	Average.
I. {	5 : 1	10	9	...	...	90	8.5
		8		...		7.5	
II. {	10 : 1	19	22	...	5	45.0	45.9
		25		5		46.8	
III. {	20 : 1	43	42.5	43	41	96.0	96.0
		42		39		96.0	
IV. {	30 : 1	41	41.0	40	41	96.0	99.5
		41		41		102.9	
V. {	40 : 1	36	45.0	35	44	102.0	99.3
		54		52		96.6	
VI. {	50 : 1	48	48.0	48	46	97.5	94.8
		48		43		92.1	

No. of pots.	CaO : MgO	Number of stalks.		Number of ears.		Aver. length of stalks.	
		p. pot.	Average.	p. pot.	Average.	of each pot	Average.
VII.	60 : 1	.. 1)	500	...	47	...	97.5
		pot 2		50		47	
VIII.	80 : 1	51	49.5	51	49	93.0	95.9
		pot 2		48		47	

Table III.

No. of pots.	CaO : MgO	Seeds g	Stalks g	Chaff g	Root g	Total g	Average p. pot g	
							Seeds	Total
I.	5 : 1 <sup>1)</sup>	.....	.....	.....	.....	.....	.....	.....
		pot 2	.....	.....	.....	.....	.....	.....
II.	10 : 1 <sup>2)</sup>	.....	13.50	.....	1.88	15.38	0.38	26.26
		pot 2	0.38	28.88	0.38	7.50		
III.	20 : 1	18.38	79.50	4.50	15.75	118.13	25.69	128.26
		pot 2	33.00	82.88	3.75	18.75		
IV.	30 : 1	29.63	82.50	6.00	18.13	136.26	31.51	135.45
		pot 2	33.38	81.00	4.13	16.13		
V.	40 : 1	25.13	72.38	3.75	16.50	117.76	20.26	144.39
		pot 2	15.38	121.50	4.88	29.25		
VI.	50 : 1	24.75	104.63	6.00	15.00	150.38	26.82	144.58
		pot 2	28.88	92.63	4.13	13.13		

1). Some plants in this pot were attacked by fungus and cut off before ripening.

2). In these two cases it is very probable that not only a certain excess of available magnesia, but also the salt concentration itself, caused the depression of the yield. All soluble salts, though not directly injurious to the plant, would perhaps cause the depression when applied in such concentration.



No. of pots.	CaO : MgO	Seeds g	Stalks g	Chaff g	Root g	Total g	Average p. pot g	
							Seeds.	Total.
VII.	60 : 1	.....	.....	.....	.....	.....	52.13	159.01
		52.13	88.88	6.00	12.00	159.01		
VIII.	80 : 1	40.50	98.25	6.38	18.00	163.13	41.63	157.70
		42.75	91.50	4.88	13.13	152.26		

The above result shows clearly that in the presence of lime as carbonate, the necessary amount of magnesia applied in the form of crystallized sulphate for barley in sand culture is so small that the best ratio of lime to magnesia becomes 60 : 1, while in the form of nitrates of calcium and magnesium in water culture the best ratio for Gramineae between 1/1 and 2/1. This conclusion will hold good also for various sandy soils, while for clayey soils the best ratio is  $\frac{\text{CaO as carbonate}}{\text{MgO as sulphate}}$  will differ, as T. NAKAMURA<sup>1)</sup> ascertained. The calculation from the above results shows that with barley 4.9 parts  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$  are agronomically equivalent to 100 parts magnesite, while with rice this equivalent is still higher viz. 9.8.

1). This Bulletin Vol. I, No. 1, P. 30-34.



## On the Manurial Effect of Calcium Cyanamide under Different Conditions.

BY

S. UCHIYAMA.

Various reports on the efficacy of Calcium cyanamide or lime-nitrogen (Kalkstickstoff) testify in favor of this compound, its action reaching about that of ammonium sulphate or sodium nitrate; other reports again contain a less favorable declaration. Evidently the nature of the soil and the nature of the other manuring compounds used along with it, have a decided influence upon the result.<sup>1)</sup> This difference of opinion can not surprise us, since the reports on the comparative efficacy of sodium nitrate and ammonium sulphate differ also very considerably. Under certain conditions, ammonium sulphate was found equal and even superior to sodium nitrate; under other conditions again inferior to this.

The publications on the new manure show among other things, that it can not be used for top-dressing and that it must be applied some time before sowing, as it would act injuriously before its decomposition by soil-bacteria, liberating its nitrogen as ammonia, is accomplished.

Since however the manurial effect of lime-nitrogen has not yet been compared with those of ammonium sulphate and sodium nitrate under conditions of different reaction of the total manure, it seemed to me of special interest to carry on some experiments along this line. Since lime-nitrogen can be decomposed by various kinds of bacteria into calcium carbonate and ammonia,  $\text{CaCN}_2 + 3\text{H}_2\text{O} = \text{CaCO}_3 + 2\text{NH}_3$  it must be defined

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1). Compare especially the publications of E. Schulze, Feilitzen, Roessler, Seelhorst, Strohmmer, Stutzer and Aso.

as an alkaline manure, while ammonium sulphate is defined as a physiologically acid nitrogenous manure. Since the ammonia formed by the decomposition of lime-nitrogen will of course rapidly be transformed into carbonate, the question as to which is the best source of nitrogen would be simplified to this: *Under which conditions is ammonium carbonate better than ammonium sulphate or sodium nitrate?*

Kossowitch as well as Prianishnikow have demonstrated recently the injury by too alkaline or too acid reactions. Also here at this stations as well as at the college of agriculture at Komaba near Tokyo similar observations have been made at about the same time. Thus it was observed by myself that ammonium sulphate in conjunction with secondary sodium phosphate produced a much better yield with *Brassica chinensis* than when the former was applied in conjunction with superphosphate. Since lime-nitrogen is an actually alkaline manure, an addition of an acid phosphatic manure would act here favorably—just the opposite from ammonium sulphate.

The sample of lime-nitrogen at my disposal contained 18.58 % N and 56.16 % CaO; the ammonium sulphate<sup>1)</sup>=20.65 % N; the crude potassium sulphate=47.55 % K<sub>2</sub>O; the double superphosphate=40.42 % P<sub>2</sub>O<sub>5</sub> soluble in water; and the secondary sodium phosphate was the pure preparation.

#### I. Experiment with *Hordeum sativum*.

Eighteen porcelain pots (area=1/200,000 ha.) were filled each with 14.27 kilo. fresh alluvial loam poor in humus, and received the following manures:

A	{	8.752 g. ammonium sulphate
	{	4.60 g. double superphosphate
	{	3.91 g. potassium sulphate
	{	8.44 g. sodium sulphate
B	{	8.752 g. ammonium sulphate
	{	9.38 secondary sodium phosphate
	{	3.91 g. potassium sulphate

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1). The ammonium sulphate in this experiment was the pure preparation.

- C { 10.0 g. lime-nitrogen  
4.6 g. double superphosphate  
3.91 g. potassium sulphate  
8.44 g. sodium sulphate
- D { 10.0 g. lime-nitrogen  
9.38 g. secondary sodium phosphate  
3.91 g. potassium sulphate

Of these four mixtures, A was decidedly acid, D decidedly alkaline, while B and C approached the neutral reaction. Further, in order to provide the pots A and B with as much lime as was contained in the lime-nitrogen, 17.27 g, gypsum were added to these pots on Sept. 7. Gypsum was selected in order not to change chemically the ammonium sulphate; and in order to observe here at the same time the difference in action between gypsum and limestone, two other pots A' and B' were prepared in which the equivalent amount of powdered limestone was added on Sept. 7. By this addition, perhaps a little of ammonium sulphate was gradually transformed into ammonium carbonate, the same product which also would be the active principle in the pots C and D. While ammonium carbonate in high dilution is probably more favorable than ammonium sulphate, some loss of this compound by volatilization may take place from soils of little absorptive power, so that the benefit produced in one respect may be frustrated by a disadvantage in another. The following table shows the manuring data, g :

Manure.	A	A'	B	B'	C	D
Ammonium sulphate ... ..	8.752	ditto	ditto	ditto	—	—
Lime-nitrogen ... ..	—	—	—	—	10.0	ditto
Double superphosphate ... ..	4.60	ditto	—	—	4.60	—
Secondary sodium phosphate...	—	—	9.38	ditto	—	9.38
Potassium sulphate... ..	3.91	ditto	ditto	ditto	ditto	ditto
Sodium sulphate ... ..	8.44	ditto	—	—	8.44	—
Gypsum ... ..	17.27	—	17.27	—	—	—
Lime-stone ... ..	—	10.03	—	10.03	—	—

On Nov. 13, 1905, lime-nitrogen was applied. The pots were kept in a warm house and well moistened in order to accelerate the decomposition of lime-nitrogen. After a week, the other manures were applied. Hence each pot contained 1.858 g N, 1.858 g  $P_2O_5$ , 1.859 g  $K_2O$ , 1.626 g  $Na_2O$ , and 5.618 g CaO.

On Nov. 21, twenty seeds of sixsided barley were sown per pot. After three weeks, the young plants were reduced to 15 per pot of about equal size. The following table shows the height of the plants and number of stalks at two different periods; and the photograph (Plate XXIV, Fig. 1) the development on May 15.

Average of three parallel pots.

N-Manure.	Group.	Jan. 17.		May 24.	
		Height (Cm.).	No. of stalks.	Height (Cm.).	No. of stalks.
$(NH_4)_2SO_4$	A	13.7	32	97.3	53
	A'	14.2	30	104.8	53
	B	13.9	32	98.2	51
	B'	12.4	26	99.7	50
CaCN <sub>2</sub>	C	13.9	39	102.4	50
	D	13.3	31	98.5	50

The plants were harvested June 3:

Harvest, average of three parallel pots; air-dry, g.

N-Manure.	Group.	Grains.	Straw.	Chaffs.	Total.	Comparative yield total.
$(NH_4)_2SO_4$	A	62.40	79.63	4.83	146.86	107
	A'	48.20	87.00	6.50	141.70	103
	B	58.77	84.57	5.20	148.54	108
	B'	51.53	86.67	4.60	142.80	104
CaCN <sub>2</sub>	C	56.00	87.40	4.85	148.25	108
	D	48.50	83.73	5.30	137.53	100

It is therefore clear that lime-nitrogen acted better when the phosphatic manure was superphosphate (C) than when it was sodium phosphate (D); in other words, *the neutral mixture (C) was better than the alkaline mixture (D)*. The manuring effect of lime-nitrogen in C was here equal to that of ammonium sulphate in B, when this was applied in conjunction with sodium phosphate.

## II. Experiment with *Brassica Chinensis*.

The soil was an alluvial loam, almost free of humus. Eighteen porcelain pots (area = 1/200,000 ha.) were filled each with 14.27 kilo. of the fresh soil, and manured<sup>1)</sup> as follows, g :

Manure.	A	A'	B	B'	C	D
Ammonium sulphate ... ..	12.0	ditto.	ditto.	ditto.	—	—
Lime-nitrogen... ..	—	—	—	—	13.34	ditto.
Double superphosphate ... ..	2.2	ditto.	—	—	2.2	—
Secondary sodium phosphate...	—	—	4.5	ditto.	—	4.5
Potassium sulphate... ..	5.2	ditto.	ditto.	ditto.	ditto.	ditto.
Sodium sulphate ... ..	4.05	ditto.	—	—	4.05	—
Gypsum ... ..	23.03	—	23.03	—	—	—
Lime-stone ... ..	—	13.38	—	13.38	—	—

Each pot contained therefore 2.478 g. N, 0.89 g.  $P_2O_5$ , 2.473 g.  $K_2O$ , 0.78 g.  $Na_2O$ , and 7.493 g.  $CaO$ .

Twenty seeds of *Brassica chinensis* were sown per pot Sept. 29. After two weeks, the plants were reduced to seven per pot of about equal size. The length and number of leaves on Nov. 7 were as follows :

1). To the corresponding pots, the lime-nitrogen, gypsum, and lime-stone were applied Sept. 7, the phosphatic manures a week later, and the other manures were applied still a week later, in solution.

Average of three parallel pots.

N-Manure.	Group.	Length (cm.).	No. of leaves.
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	A	23.3	61
	A'	22.7	56
	B	22.1	57
	B'	22.5	57
CaCN <sub>2</sub>	C	23.9	56
	D	21.8	56

The adjoining Plate XXIV, Fig. 2 shows the state of development at that time.

The plants were harvested Nov. 13 with the following result, g. :

Average of three parallel pots.

N-Manure.	Group.	Fresh state.			Air-dry state.		
		Leaves.	Roots.	Total	Leaves.	Roots.	Total.
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	A	169.2	9.0	178.2	18.2	1.3	19.5
	A'	156.3	8.2	164.5	17.7	1.1	18.8
	B	182.8	10.2	193.0	20.2	1.4	21.6
	B'	173.3	8.8	182.1	19.1	1.2	20.3
CaCN <sub>2</sub>	C	177.4	11.7	189.1	19.7	1.5	21.2
	D	155.6	10.5	166.1	17.4	1.3	18.7

If we now assume the total yield (in the air-dry state) of the pots D to be = 100, we obtain the following ratio :



N-Manure.	Group.	Comparative yield.
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	A	104
	A'	101
	B	116
	B'	109
CaCN <sub>2</sub>	C	113
	D	100

The result shows that lime-nitrogen acted better when the phosphatic manure was superphosphate (C) than when it was sodium phosphate (D); in other words: *the neutral mixture (C) was better than the alkaline mixture (D)*. The physiologically acid ammonium sulphate acted however better with sodium phosphate (B) than with superphosphate (A); also this result leads to the inference: *the neutral reaction of the total manure in B was more favorable than the acidic reaction in A*.

The moderate dose of calcium carbonate in A' and B' was of no special effect in connection with the ammonium sulphate, but this can be easily understood, because the soil contained already some carbonate of lime.

### III. Second Experiment with *Brassica Chinensis*.

*The amount of nitrogen was here diminished to one third of that in the preceding experiment, and two different kinds of soils<sup>1)</sup> i.e. diluvial loamy and alluvial sandy soils served for the test. Forty eight zinc pots (area = 1/200,000 ha.) were filled with the respective soils (15.75 kilo. per pot). Twelve series were prepared, each consisting of four pots. To the respective pots, the following manures were applied, g :*

1). The loamy soil from the upland of our station is very rich in humus, while the sandy soil from the paddy field of Kawaguchi near Tokyo is almost free from organic matter.

Manure.	A	A'	B	B'	C	D
Ammonium sulphate ... ..	4.0	ditto.	ditto.	ditto.	—	—
Lime-nitrogen ... ..	—	—	—	—	4.45	ditto.
Double superphosphate ... ..	2.2	ditto.	—	—	2.2	—
Secondary sodium phosphate...	—	—	4.5	4.5	—	4.5
Potassium sulphate... ..	4.0	ditto.	ditto.	ditto.	ditto.	ditto.
Sodium sulphate ... ..	4.05	ditto.	—	—	4.05	—
Gypsum ... ..	7.68	—	7.68	—	—	—
Lime-stone ... ..	—	4.46	—	4.46	—	—

On December 25, lime-nitrogen was applied, while four months later the other manuring ingredients. Hence each pot contained 0.83 g. N, 0.89 g.  $P_2O_5$ , 1.90 g.  $K_2O$ , 0.78 g.  $Na_2O$  and 2.50 g.  $CaO$ . On April 11, twenty seeds of *Brassica Chinensis* were sown per pot. The young plants appeared five days later in all pots with the loamy soil, while the germination in all pots with the sandy soil commenced two days later. On April 25, the young plants were thinned to eight of about equal size.

During vegetation, the plants of the pots B in both series seemed most luxuriant. The following table shows the average length of leaves measured on May 21 :

Averaged of four parallel pots.

Soil.	N-Manure	Group.	Length (cm.).
L. amy soil	$(NH_4)_2SO_4$	A	26.1
		A	25.2
		B	28.8
		B'	27.1
	$CaCN_2$	C	25.2
		D	26.1

Soil.	N-manure.	Group.	Length (cm.).
Sandy soil	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	A	25.2
		A'	27.0
		B	27.6
		B'	27.3
	CaCN <sub>2</sub>	C	22.7
		D	21.5

The plants were harvested May 21 with the following result, g. :

Average of four parallel pots.

Soil.	N-manure.	Group.	Fresh state.			Air-dry state.				
			Leaves.	Roots.	Total.	Leaves.	Roots.	Total.		
Loamy soil	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	A	192.06	11.90	203.96	22.98	1.50	24.48		
		A'	188.55	12.20	200.75	22.53	1.35	23.88		
		B	217.38	14.25	231.63	24.33	1.53	25.86		
		B'	210.17	12.93	223.10	22.57	1.53	24.10		
	CaCN <sub>2</sub>	C	165.79	14.40	180.19	19.07	1.60	20.67		
		D	159.89	14.07	173.96	18.13	1.77	19.90		
		Sandy soil	(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	A	186.60	13.38	199.98	17.80	1.30	19.10
				A'	176.44	10.50	186.94	17.90	0.98	18.88
B	189.65			12.83	202.48	18.75	1.25	20.00		
B'	178.66			12.23	190.89	18.65	1.25	19.90		
CaCN <sub>2</sub>	C	113.25	13.50	126.75	12.37	1.37	13.74			
	D	113.71	10.90	124.61	12.35	1.10	13.45			

1). With sandy soil the maximum harvest was obtained from the pots B. In the pots B, the average weight of one plant was 2.5 g. (20.8=2.5) and average yield from one kilo. soil amounted to 1.27 g. (20/15.75=1.27), while one plant of the corresponding pots in the preceding experiment with a large supply of nitrogen amounted to 3.1 g. (21.6/7=3.1) and one kilo. soil produced 1.51 g. (21.6/14.27=1.51).

If we now assume the total yield (in the air-dry state) of the pots D in each case of soil respectively to be = 100, we obtain the following ratio :

Soil.	N-manure.	Group.	Comparative yield.
Loamy soil	$(\text{NH}_4)_2\text{SO}_4$	A	123
		A'	120
		B	130
		B'	121
	$\text{CaCN}_2$	C	104
		D	100
Sand soil	$(\text{NH}_4)_2\text{SO}_4$	A	142
		A'	140
		B	149
		B'	148
	$\text{CaCN}_2$	C	102
		D	100

The manurial effect of lime-nitrogen, was in this case, with a small dose of nitrogen, far smaller than that of ammonium sulphate. This difference of the manurial effects between lime-nitrogen and ammonium sulphate was further much larger in the case of sandy soil than in the case of loamy soil. In the case of loamy soil, if we assume the comparative yield from the group B (130) to be = 100, and compare the respective yield from the group C (104), we obtain the following ratio :

Ammonium sulphate.	Lime-nitrogen.
100	80

The comparative yields in the case of sandy soil would be :

Ammonium sulphate.	Lime-nitrogen.
100	69

IV. General Conclusion,

- 1). The manurial effect of lime-nitrogen varies greatly with the reaction of the other manuring compounds : it acts best when the total reaction in the soil approaches neutrality.
  - 2). The manurial effect of ammonium sulphate varies also greatly with the reaction of the other manuring compounds : it acts better when sodium phosphate than when superphosphate is applied along with it. Also from this fact, it must be inferred that ammonium sulphate acts best when the reaction of the total manure approaches neutrality.
  - 3). The manurial effect of lime-nitrogen is under favorable conditions equal (see barley experiment) to that of ammonium sulphate ; but when the nitrogenous manures are compared in small applications, ammonium sulphate proved superior. This result may be due to the changed state of the reaction.
  - 4). On sandy soil, the action of lime-nitrogen was farther below that of ammonium sulphate than on loamy soil.
-

## EXPLANATION OF PLATE XXIV.

Fig. 1.

- A<sub>3</sub> Manured with 8.752 g. ammonium sulphate, 4.6 g. double superphosphate, 3.91 g. potassium sulphate, 8.44 g. sodium sulphate, and 17.27 g. gypsum.
- A'<sub>2</sub> Manured like A<sub>3</sub>, but gypsum was here substituted by 10.03 g. limestone meal.
- B<sub>3</sub> Manured with 8.752 g. ammonium sulphate, 9.38 g. secondary sodium phosphate, 3.91 g. potassium sulphate and 17.27 g. gypsum.
- B'<sub>2</sub> Manured like B<sub>3</sub>, but gypsum was here replaced by 10.03 g. limestone meal.
- C<sub>1</sub> Manured with 10 g. lime-nitrogen, 4.6 g. double superphosphate, 3.91 g. potassium sulphate and 8.44 g. sodium sulphate.
- D<sub>3</sub> Manured with 10 g. lime-nitrogen, 9.38 g. secondary sodium phosphate and 3.91 g. potassium sulphate.

Fig. 2

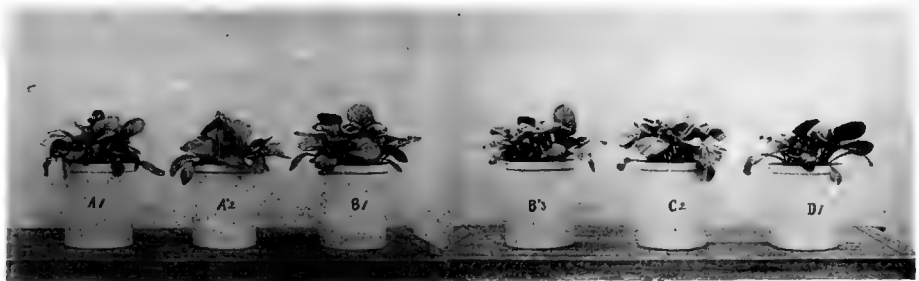
- A<sub>1</sub> Manured with 12 g. ammonium sulphate, 2.2 g. double superphosphate, 5.2 g. potassium sulphate, 4.05 g. sodium sulphate, and 23.03 g. gypsum.
- A'<sub>2</sub> Manured like A<sub>1</sub>, but gypsum was here replaced by 13.38 g. limestone meal.
- B<sub>1</sub> Manured with 12 g. ammonium sulphate, 4.5 g. secondary sodium phosphate, 5.2 g. potassium sulphate, and 23.03 g. gypsum.
- B'<sub>1</sub> Manured like B<sub>1</sub>, but gypsum was here substituted by 13.38 g. limestone meal.
- C<sub>2</sub> Manured with 13.34 g. lime-nitrogen, 2.2 g. double superphosphate, 5.2 g. potassium sulphate and 4.05 g. sodium sulphate.
- D<sub>1</sub> Manured with 13.34 g. lime-nitrogen, 4.5 g. secondary sodium phosphate and 5.2 g. potassium sulphate.
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(1)



To Page 96.

(2)



To Page 98.





## Some Observations on Manuring with Bone-dust.

BY

S. UCHIYAMA.

The observation of Kellner and Böttcher that the availability of bone dust, but not that of secondary calcium phosphate,<sup>1)</sup> Thomas phosphate and superphosphate is depressed by calcium carbonate has been repeatedly confirmed and was explained by the neutralization of the soil acidity by liming.<sup>2)</sup> In order to gain some further information the action of bone dust in the presence of gypsum and of magnesium sulphate respectively was compared with the depressions caused by the presence of the carbonates of lime, magnesia and potassa with both sand and soil cultures.

*Sand-culture*: The experiment was carried out with of barley in six series, each in three pots. Each pot contained 6 kilo. pure quartz sand, and received the following manures<sup>3)</sup>:

15.64 g. bone dust.

3.86 g. ammonium nitrate (In Series F substituted by  $\text{NaNO}_3$ )

2.7 g. potassium sulphate ( „ „ „ partly besides  $\text{K}_2\text{CO}_3$ )

0.5 g. ferric hydrate.

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1). It might therefore be supposed that carbonic acid of the soil-air suffices to render this phosphate available to the roots, while for bone dust a more powerful acid seems to be necessary to render it thoroughly available.

2). Also the acidity of the rootlets doubtless plays a part.

3). The bone dust (steamed and partly deprived of glue) was of extreme fineness,  $< 0.5$  m.m. and contained 1.39 % N, 29.58 %  $\text{P}_2\text{O}_5$ , 37.88 % CaO and 1.27 % MgO.

The magnesit contained 47.05 % MgO.

The other manuring compounds were chemically pure.

Series A, received so much magnesia in the form of 8 g. powdered magnesit (<0.5 m.m.) that the ratio  $\frac{\text{CaO}}{\text{MgO}}$  was  $= \frac{1}{1}$ . The bone dust was here the only source of lime.

Series B, contained the magnesia in the form of 0.78 g. crystallized sulphate which dose will be about agronomically equivalent in sand to 8 g. magnesit.

Series C, contained 3.42 g. lime-stone meal, every other particular=A; hereby the ratio  $\frac{\text{CaO}}{\text{MgO}} = \frac{1.5}{1}$  resulted.

Series D, contained 6.84 g. limestone meal, every particular=A; hereby the ratio  $\frac{\text{CaO}}{\text{MgO}} = \frac{2}{1}$  was produced.

Series E, like A, but 11.76 g. gypsum were added, yielding thus the ratio  $\frac{\text{CaO}}{\text{MgO}} = \frac{2}{1}$ ; but one half of the lime is here more easily available than the other half.

Series F, like A, but a certain portion of potassium sulphate was replaced by 0.4 g.  $\text{K}_2\text{CO}_3$ . Ammonium nitrate had here to be replaced by an equivalent amount of *sodium nitrate*<sup>1)</sup> in order to avoid the formation of the injurious ammonium carbonate.

The following table will show the quantitative data in regard to manuring conveniently :

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1). Seelhorst as well as Prianishnikow and Soderbaum have already observed that in the presence of sodium nitrate the phosphoric acid of rock and bone phosphate is not so easily available as in the presence of ammonium sulphate or ammonium nitrate. In the former case, sodium carbonate was believed to be gradually formed.

Manure.	A	B	C	D	E	F
Bone dust ... ..	15.64 g.	ditto.	ditto.	ditto.	ditto.	ditto.
Ammonium nitrate ...	3.86 g.	ditto.	ditto.	ditto.	ditto.	—
Sodium nitrate ... ..	—	—	—	—	—	8.19 g.
Potassium sulphate ...	2.7 g.	ditto.	ditto.	ditto.	ditto.	2.2 g.
Potassium carbonate ...	—	—	—	—	—	0.4 g.
Ferric hydrate ... ..	0.5 g.	ditto.	ditto.	ditto.	ditto.	ditto.
Magnesit ... ..	8 g.	—	8 g.	ditto.	ditto.	ditto.
Magnesium sulphate ...	—	0.78 g.	—	—	—	—
Limestone ... ..	—	—	3.42 g.	6.84 g.	—	—
Gypsum ... ..	—	—	—	—	11.76 g.	—
Ratio $\frac{\text{CaO}}{\text{MgO}}$ ... ..	$\frac{1}{1}$	$\left(\frac{1}{30}\right)$	$\frac{15}{1}$	$\frac{2}{1}$	$\frac{2}{1}$	$\frac{1}{1}$

On Nov. 4, 1904, bone dust, magnesit, limestone, gypsum, and ferric hydrate,<sup>1)</sup> were applied to the respective pots; and a part of the soluble nutrients the next day in solution, the rest Feb. 20.

On December 12, the young plants of sixsided barley of about 6 cm. were transplanted, each pot receiving three bundles, each consisting of three plants. During vegetation, the plants of the pots B and E showed a most luxuriant development and a *deep green color*, while those of the other pots showed a poor growth and a somewhat pale color; the poorest of all were the plants in E. The following table shows the height of plants, and numbers of stems and ears :

1). The ferric hydrate was freshly precipitated and applied in suspension.

## Average of three parallel pots.

	January 17.		May 24.	
	Height (cm.).	No. of stems.	Height (cm.).	No. of ears.
A	16.7	24	85.5	18
B	16.4	25	79.1	18
C	16.1	24	87.9	14
D	17.0	25	76.1	11
E	17.9	24	80.6	19
F	16.1	25	60.6	7

The adjoining Plate xxv, Fig. 1 (photogr. May 12) shows the difference in development. The ears appeared gradually, about two weeks passing between the earliest and latest sproutings; the differences will be seen from the following table:

## Average of three parallel pots.

	Ears appeared.
A	May 1
B	April 26
C	May 4
D	" 8
E	April 24
F	May 9

The plants were harvested June 10, and weighed in the air-dry state with the following result, g.:

Average of three parallel pots.

	Grains.	Straw.	Chaffs.	Roots.	Total.
A	17.95	26.60	3.30	4.30	52.15
B	17.00	30.20	2.00	5.13	54.33
C	17.27	23.57	1.50	4.07	46.41
D	11.83	17.57	1.17	4.07	34.64
E	22.10	31.45	2.60	6.75	62.90
F	6.90	8.80	0.60	1.80	18.10

If we now assume the total yield of the pots B to be = 100, we obtain the following ratio :

A ( $MgCO_3$ )	...	...	...	...	...	96
B ( $MgSO_4$ )	...	...	...	...	...	100
C ( $CaCO_3 + MgCO_3$ )	...	...	...	...	...	85
D ( $CaCO_3 + MgCO_3$ )	...	...	...	...	...	64
E ( $CaSO_4 + MgCO_3$ )	...	...	...	...	...	116
F ( $K_2CO_3 + MgCO_3$ )	...	...	...	...	...	33

From the observations and this yield, it may be inferred :

1. Magnesit acts like limestone, depressing the availability of bone dust (compare A, C and D with B)<sup>1)</sup>.
2. The ratio  $CaO : Mg = 2 : 1$  (D) depressed the harvest more than the ratio  $CaO : Mg = 1 : 1$  (A) which is in full accordance with results obtained also in other cases with cereals.

1). Recently Koch and Gröter (Fühlings Landw. Zeitg. 1906, p. 225) inferred from their experiments that this depressing effect is also due to the neutralization of the acids produced by bacteria in the soil. But the conditions in the soil are often entirely different from those in flasks. These authors applied solutions of 2-5 % dextrose to bone dust in the absence and in the presence of calcium carbonate, and of course observed that in the absence of calcium carbonate the phosphate was dissolved considerably by the bacterial action. But in the soil, suitable carbohydrates are generally absent, and therefore acid can not be produced. On the contrary, the soil-bacteria produce ammonium carbonate by the rotting process of the organic matter of the bone dust, and in this case the solubility of the tertiary phosphates will certainly be very much smaller than in the former case, i.e. in the presence of glucose.

3. Even a certain excess of gypsum produced the most favorable result. The different availability of calcium carbonate and sulphate<sup>1)</sup> partly accounts for the fact that here the ratio  $\text{CaO} : \text{MgO} = 2 : 1$ <sup>2)</sup> did not depress the harvest.
4. In the presence of sodium nitrate, the phosphoric acid of bone phosphate is not so easily available as in the presence of ammonium sulphate (compare F with the other pots) in accordance with the results of other investigators.
5. In the pot E with 0.4 g. potassium carbonate, the harvest was poorest; but in how far this was due to the substitution of ammonium nitrate by sodium nitrate and in how far to the increased alkaline reaction caused by potassium carbonate, could not directly be decided.
6. Since the plants grown with gypsum were of a deeper green than those grown with carbonates, it seems that the chlorophyll production was also somewhat interfered with in the latter cases. Further, investigations on this point however are contemplated.

The above observations with sand-culture rendered it desirable to compare also in soil-culture the effect of potassium carbonate and also of wood ash with that of potassium sulphate, when bone dust serves as a phosphatic manure.

*Soil-culture* : An alluvial sandy soil poor in humus was selected for this purpose, since the presence of much humus would have led probably to the neutralization of potassium carbonate.

#### Experiment with Barley.

The experiment was carried out in two parallel series. Eight zinc pots received 10 kilo. air-dry soil. On Nov. 4, 1904, 6 g. sodium

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1). O. Loew and K. Aso: "On Different Degrees of Availability of Plant Nutrients," The Bulletin, Col. of Agric., Tokyo, Vol. VI., No. 4, p. 335.

2). One plant showed here an average weight of 7 g. in the air-dry state, which is certainly a good result for sand-culture.

nitrate<sup>1)</sup> and 2 g. bone dust<sup>2)</sup> were applied as general manure to each pot. While 1.61 g potassium carbonate<sup>3)</sup> was added to each of the first two pots, each of the second two pots received as much wood ash<sup>4)</sup> as corresponded to potassium carbonate so that the potassa content was equal. Each of the third two pots with wood ash received less bone dust than the others, since the wood ash itself contained 3.5 %  $P_2O_5$ . This amount was calculated as bone dust and subtracted from the 2 g. bone dust applied to the other pots; probably the phosphoric acid in the wood ash is also present chiefly as tertiary calcium phosphate. To make up the difference in nitrogen the amount of sodium nitrate was raised to 6.2 g. In each of the fourth two pots, the potassa was applied as sulphate<sup>5)</sup> in doses equivalent to the potassium carbonate, applied to the others. The following table gives the quantitative data in regard to manuring :

Nutrients.	I	II	III	IV
Sodium nitrate ... ..	6.0 g.	ditto.	6.2 g.	6.0 g.
Bone dust ... ..	2.0 g.	ditto.	0.8 g.	2.0 g.
Potassium carbonate ... ..	1.61 g.	—	—	—
Wood ash ... ..	—	9.5 g.	ditto.	—
Potassium sulphate ... ..	—	—	—	1.94 g.
Total nitrogen ... ..	1.01 g.	ditto.	ditto.	ditto.
„ phosphoric acid ... ..	0.56 g.	0.89 g.	0.56 g.	ditto.
„ potassa... ..	1.05 g.	ditto.	ditto.	ditto.

On Nov. 6, twenty seeds of sixsided barley were sown per pot, and after nine days the young shoots came up almost simultaneously. The

1). Sodium nitrate (16 % N) was intentionally applied as a source of nitrogen, since ammonium sulphate, being physiologically acid, would have interfered with the alkalinity of the manure (potassium carbonate and wood ash), the effect of which was to be observed.

2). The bone dust (steamed and partly deprived of glue) was of extreme fineness, <0.5 m.m., and contained 2.71 % N and 27.73 %  $P_2O_5$ .

3). The potassium carbonate contained 65 %  $K_2O$ .

4). The wood ash contained 11 %  $K_2O$ , and 3.50 %  $P_2O_5$ .

5). The potassium sulphate contained 54 %  $K_2O$ .

plants were thinned to 15 per pot on December 7, taking care that they were all equal in size.

During vegetation, the plants showed no very great differences, as will be seen from the following table :

Average of two parallel pots.

Group.		I	II	III	IV
Manures per pot.		6 g. $\text{NaNO}_3$ 2 g. bone dust 1.61 g. $\text{K}_2\text{CO}_3$	6 g. $\text{NaNO}_3$ 2 g. bone dust 9.5 g. wood ash	6.2 g. $\text{NaNO}_3$ 5.8 g. bone dust 9.5 g. wood ash	6 g. $\text{NaNO}_3$ 2 g. bone dust 1.94 g. $\text{K}_2\text{SO}_4$
Dec. 7	Height of plants (cm.)	7.8	9.2	8.3	8.1
	No. of shoots ... ..	15	15	15	15
Jan. 17	Height of plants (cm.)	12.0	13.7	12.1	11.8
	No. of shoots ... ..	51	56	15	53
Feb. 2	Height of plants (cm.)	17.2	19.4	16.8	17.1
	No. of shoots ... ..	70	59	60	61
March 20	Height of plants (cm.)	28.9	29.5	31.1	26.3
	No. of shoots ... ..	71	68	68	71
April 19	Height of plants (cm.)	70.9	73.5	79.6	73.2
	No. of shoots ... ..	41	37	33	39
May 26	Height of plants (cm.)	103.2	110.8	103.0	104.7
	No. of ears ... ..	34	31	31	33

The plants were harvested on June 5, and weighed in the air-dry state with the following result, g. :



## Average of two parallel pots.

Group.	I	II	III	IV
Manures per pot.	6 g. $\text{NaNO}_3$ 2 g. bone dust 1.61 g. $\text{K}_2\text{CO}_3$	6 g. $\text{NaNO}_3$ 2 g. bone dust 9.5 g. wood ash	6.2 g. $\text{NaNO}_3$ 0.8 g. bone dust 9.5 g. wood ash	6 g. $\text{NaNO}_3$ 2 g. bone dust 1.94 g. $\text{K}_2\text{SO}_4$
Grains ... ..	49.8	54.5	50.2	52.0
Straw ... ..	51.2	52.9	49.9	47.5
Chaffs ... ..	4.0	3.9	3.9	4.2
Total ... ..	105.0 <sup>1)</sup>	111.3	104.0	103.7 <sup>2)</sup>

If we now assume the total yield with the manure of the group IV to be = 100, we obtain the following ratio :

I	II	III	IV
101	107	100	100

Hence there was no decisive difference between the effects of potassium sulphate and potassium carbonate when the nitrogen was added as nitrate.

## Experiment with Soy-bean.

Eight zinc pots were manured as follows :

1). The weight of one plant in the group I would therefore be 7 g. in the air-dry state ( $105 \div 15 = 7$ ).

2). The average weight of one plant in the group IV was again 7 g. ( $103.7 \div 15 = 7$ ). In the first experiment, when bone dust was applied together with ammonium nitrate and gypsum, the average weight of one plant was also 7 g. ( $62.7 \div 9 = 7$ ).

Nutrients <sup>1)</sup>	I	II	III	IV
Sodium nitrate ... ..	2.84 g.	ditto.	3.1 g.	2.84 g.
Bone dust ... ..	6.0 g.	ditto.	4.04 g.	6.0 g.
Potassium carbonate ... ..	2.5 g.	—	—	—
Wood ash ... ..	—	15.5 g.	15.5 g.	—
Potassium sulphate ... ..	—	—	—	3.2 g.
Total nitrogen ... ..	0.61 g.	ditto.	ditto.	ditto.
„ phosphoric acid ... ..	1.66 g.	2.29 g.	1.66 g.	ditto.
„ potassa... ..	1.70 g.	ditto.	ditto.	ditto.

Ten seeds of soy-bean previously steeped in water were sown per pot June 6. The young shoots appeared after five days, except in pots IV ( $K_2SO_4$ ), which came up three days later. The plants were reduced later on to six per pot of about equal size. All plants showed nearly equal development, only those of the pots II seemed always somewhat a head<sup>2)</sup>. The following table shows the height of the plants on Sept. 21 :

Average of two parallel pots.

Group.	I	II	III	IV
Manures per pot.	2.84 g. $NaNO_3$ 6 g. bone dust 2.5 g. $K_2CO_3$	2.84 g. $NaNO_3$ 6 g. bone dust 15.5 g. wood ash	3.1 g. $NaNO_3$ 4.04 g. bone dust 15.5 g. wood ash	2.84 g. $NaNO_3$ 6 g. bone dust 3.2 g. $K_2SO_4$
Height (cm.) ...	54.1	57.1	52.3	54.5

The plants were harvested on Sept. 21, and weighed in the air-dry state with the following result, g. :

1). The nutrients were the same as those applied in the former experiment, except the sample of potassium carbonate which was here quite pure.

2). In the pots II the amount of phosphoric acid was larger than in the other pots, since the phosphoric acid of the wood ash was added to the dose of bone dust in I and IV.

## Average of two parallel pots.

Group.	I	II	III	IV
Manures per pot.	2.84 g. NaNO <sub>3</sub> 6 g. bone dust 2.5 g. K <sub>2</sub> CO <sub>3</sub>	2.84 g. NaNO <sub>3</sub> 6 g. bone dust 15.5 g. wood ash	3.1 g. NaNO <sub>3</sub> 4.04 g. bone dust 15.5 g. wood ash	2.80 g. NaNO <sub>3</sub> 6 g. bone dust 3.2 g. K <sub>2</sub> SO <sub>4</sub>
Grains ... ..	52.67	53.99	49.73	50.96
Stalks, husks, roots etc.	65.35	74.79	65.03	62.35
Total ... ..	118.02	128.78	114.76	113.31

If we now assume the total yield with the manure of the group IV to be = 100, we obtain the following ratio :

I	II	III	IV
104	114	101	100

This result coincides with that of the former experiment with barley.

## Second Experiment with Barley.

This experiment was carried out in three parallel series, and with a different soil (alluvial sand). In order to examine here the productivity of the original phosphoric acid in the soil, pots without phosphatic manure served for comparison. On October 29, fifteen zinc pots received each 12 kilo. air-dry soil with the following manures<sup>1)</sup>.

1). Each manure had the following percentage amount of nutrient :

The sodium nitrate = 13.92 % N.

The wood ash = 17.24 % K<sub>2</sub>O and 3.14 % P<sub>2</sub>O<sub>5</sub>.

The other manuring compounds were the same as in the former experiment with barley in sand-culture.

Nutrients.	I	II	III	IV	V
Sodium nitrate ... ..	20.25 g.	ditto.	20.6 g.	20.25 g.	21.25 g.
Bone dust ... ..	10.0 g.	ditto.	6.47 g.	10.0 g.	—
Potassium carbonate ...	8.8 g.	—	—	—	—
Wood ash ... ..	—	34.8 g.	ditto.	—	—
Potassium sulphate ...	—	—	—	11.09 g.	ditto.
Total nitrogen ... ..	2.96 g.	ditto.	ditto.	ditto.	ditto.
„ phosphoric acid...	2.96 g.	4.05 g.	3.00 g.	2.96 g.	—
„ potassa ... ..	5.99 g.	ditto.	ditto.	ditto.	ditto.

On December 15, the young plants of six-sided barley of about 6 cm. were transplanted so that each pot received five bundles, each consisting of three plants. During vegetation, all plants with bone dust (I, II, III, and IV) developed almost equally well, while those without phosphatic manure (V) showed a poor growth, as will be recognized from the following table :

Average of three parallel pots.

Group.	I	II	III	IV	V
Manures of pot.	20.25 g. NaNO <sub>3</sub> 10 g. bone dust 7.8 g. K <sub>2</sub> CO <sub>3</sub>	20.25 g. NaNO <sub>3</sub> 10 g. bone dust 34.8 g. wood ash	20.60 g. NaNO <sub>3</sub> 6.47 g. bone dust 34.8 g. wood ash	20.25 g. NaNO <sub>3</sub> 10 g. bone dust 11.09 g. K <sub>2</sub> SO <sub>4</sub>	No phosphatic manure
Jan. 17					
Height of plants (cm.)	14.2	13.4	13.9	14.0	14.5
No. of stems	35	36	34	36	30
May 24					
Height of plants (cm.)	99.8	96.2	94.0	94.3	78.0
No. of ears	36	36	36	37	21

The adjoining plate (photogr. May 24) xxv, Fig. 2 shows the general development.

The plants were harvested June 8, and weighed in the air-dry state with the following result, g. :

## Average of three parallel pots.

Group.	I	II	III	IV	V
Manures of pot.	20.25 g. NaNO <sub>3</sub> 10 g. bone dust 7.8 g. K <sub>2</sub> CO <sub>3</sub>	20.25 g. NaNO <sub>3</sub> 10 g. bone dust 34.8 g. wood ash	20.6 g. NaNO <sub>3</sub> 6.47 g. bone dust 34.8 g. wood ash	20.25 g. NaNO <sub>3</sub> 10 g. bone dust 11.09 g. K <sub>2</sub> SO <sub>4</sub>	No phosphatic Manure.
Grains ... ..	43.9	39.6	44.3	48.7	21.2
Straw ... ..	62.2	66.5	70.1	73.7	35.0
Chaff ... ..	7.0	6.2	7.1	7.5	4.1
Total ... ..	113.1⊕	112.3	121.5	129.9⊕	60.3

If we now assume the total yield with the manure of the group IV to be = 100, we obtain the following ratio :

I	II	III	IV	V
87	86	94	100	46

From these results, which differ partly from those obtained with plain sand-culture (see above) it may be concluded that the harvests of barley obtained on sandy soils with *bone dust and sodium nitrate as manure do not show great differences when in one case the potassa is supplied as potassium sulphate and in the other as potassium carbonate*. On one soil, the result was nearly equal, while on the second soil, potassium sulphate yielded a somewhat better result. Also the potassa in the form of wood ash yielded a result not behind the other case. *Wood ash and bone dust may therefore be applied together.*

This behavior of potassium carbonate in the soil manured with bone dust required some further chemical examination, for there was a direct action of it on the bone dust possible with gradual formation of potassium phosphate and calcium carbonate.

⊕ The weight of one plant in the group I would therefore be 7 g. in the air-dry state and of the group IV 8 g. In the first experiment when bone dust was applied together with ammonium nitrate and gypsum the average weight of one plant was also 7 g. In the second experiment, the average weights of one plant in the pots I and IV were again 7 g.

In order to decide this question, 25 g. bone dust<sup>1)</sup> as well as equivalent doses of bone ash<sup>2)</sup> were left with frequent shaking in 2.5 litres of water as well as of 1% potassium carbonate solution for 4½ months<sup>3)</sup> at room-temperature; in one case 5 c.c. of neutral chloroform were added to prevent any bacterial action, while in the others chloroform was excluded. Phosphoric acid had indeed after that time passed into solution; therefore potassium phosphate must have been formed. The quantitative determinations in one litre of the liquid gave the following results:

		Milligr. P <sub>2</sub> O <sub>5</sub> dissolved in one litre.		
		After 1 month.	After 2 months	After 4½ months.
I	Bone dust in water ... ..	7.65	—	12.66
II	Bone ash „ „ ... ..	0.57	—	0.71
III	Bone dust in water with chloroform... ..	5.29	—	7.46
IV	Bone ash „ „ „ „ ... ..	0.19	0.51	0.64
V	Bone dust in 1% K <sub>2</sub> CO <sub>3</sub> solution ... ..	45.91	47.82	68.95
VI	Bone ash „ „ „ „ ... ..	8.16	8.99	—
VII	Bone dust in 1% K <sub>2</sub> CO <sub>3</sub> solution with chloroform	44.51	45.78	56.04
VIII	Bone ash „ „ „ „ „ „	5.42	6.89 <sup>4)</sup>	8.42

These numbers show that *the bacteria play indeed a role causing solution of phosphoric acid from bone dust* (compare I with III). In the presence of bacteria (I), the amount of dissolved phosphoric acid had increased by 70%<sup>5)</sup> after 4½ months over the amount of dissolved phosphoric acid in the presence of chloroform.

When we further<sup>1)</sup> compare II and IV, we find that the absence of chloroform has not led to any notable increase of the dissolved phosphoric

1). The bone dust was the same as that applied in the above fourth experiment.

2). The bone ash was freshly prepared by igniting 25 g. bone dust mentioned.

3). From December 26, 1905 to May 11, 1906.

4). This figure is smaller than the corresponding figure of VI (8.99), which may be due to the gradual decomposition of chloroform by the potassium carbonate, whereby potassium chloride and potassium formate result.

5). 7.46 : 12.66 = 100 : 172.

acid. This different behavior from bone dust is very easily explained by the absence of organic matter in bone ash, excluding therefore the possibility of bacterial growth.

Further more, it becomes evident that potassium carbonate has acted chemically on the bone dust with the formation of potassium phosphate, as becomes clear in comparing V and VII. The presence of chloroform in this case, depressed the dissolution of phosphoric acid comparatively little, proving that *the chemical influence of potassium carbonate on bone dust was much more powerful, than the effect of the bacterial action.*

Further it becomes clear that the potassium carbonate acts with much more difficulty on bone ash than on bone dust (Compare IV and VIII with V and VII).

As a general result, however, it follows that the depressing effect which potassium carbonate would no doubt exert on account of its alkalinity on the availability of bone dust is counterbalanced by its chemical action on bone dust in which gradually potassium phosphate and calcium carbonate are produced.

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## EXPLANATION OF PLATE XXV.

Fig. 1.

- A<sub>III</sub> Manured with 15.64 g. bone dust, 3.86 g. ammonium nitrate, 2.7 g. potassium sulphate, 0.5 g. ferric hydroxide, and 8 g. magnesit.
- B<sub>II</sub> Manured like A<sub>III</sub>, but magnesit was here substituted by 0.78 g. crystallized magnesium sulphate.
- C<sub>III</sub> Manured like A<sub>III</sub> with an addition of 3.42 g. limestone meal.
- D<sub>III</sub> Manured like C<sub>III</sub>, but the amount of limestone was here increased to 6.84 g.
- E<sub>III</sub> Manured like D<sub>III</sub>, but limestone was here replaced by the equivalent amount of gypsum (11.76 g.).
- F<sub>II</sub> Manured with 15.64 g. bone dust, 8.19 g. sodium nitrate, 2.2 g. potassium sulphate, 0.4 g. potassium carbonate, 0.5 g. ferric hydroxide and 8 g. magnesit.

Fig. 2.

- I<sub>3</sub> Manured with 20.25 g. sodium nitrate, 10 g. bone dust, and 7.8 g. potassium carbonate.
- II<sub>1</sub> Manured with 20.25 g. sodium nitrate, 10 g. bondust, and 34.8 g. wood ash.
- III<sub>3</sub> Manured with 20.6 g. sodium nitrate, 6.47 g. bone dust, and 34.8 g. wood ash.
- IV<sub>3</sub> Manured with 20.25 g. sodium nitrate, 10 g. bone dust, and 11.09 g. potassium sulphate.
- V<sub>3</sub> Received no phosphatic manure.
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(1)



To Page 108.

(2)



To Page 116.



## On the Cultivation of *Astragalus Lotoides*.

BY

T. IMASEKI.

In many districts of Japan, the farmers practice since olden times sowing the seeds of a leguminous plant called '*Genge*,' *Astragalus lotoides*, in September or October, between the rice-plants in paddy fields. This plant attains in the following spring the flowering stage before the new rice is transplanted, and it is then incorporated in the field as green manure.

This practice, which obviously causes an accumulation of nitrogen in the soil, is extending more and more throughout the rice-growing districts of Japan. But, as the accumulation of nitrogen by the *Genge*-plant is accomplished by the symbiotic growth with its root bacteria, an inoculation of these bacteria should be carried on in such districts, where the cultivation of *Genge* has not been practised before.

In order to study the best modes of inoculation, I have made a preliminary experiment. Sixteen zinc cylinders, of 2500 sq. cm. surface were filled with the soil from an unmanured field of this Experiment Station. The plan of the experiment was as follows :—

		Manure.			
		Per cylinder.		per hectare.	
		Sodium phosphate, g	Potassium carbonate, g		
I. No manure	{	a. original seed	—	—	—
	}	b. inoculated seed	—	—	—
II. Phosphoric acid and potash	{	a. original seed	18.5	5.6	{ 150 kilo. P <sub>2</sub> O <sub>5</sub> 150 " K <sub>2</sub> O " " " " " "
	}	b. inoculated seed	18.5	5.6	

Sodium phosphate and potassium carbonate were applied in solution September 23, and well mixed with the soil.

The seeds of *Genge* were at first steeped for about 24 hours in water or in the water containing nodule bacteria, which had been prepared in pure culture. The seeds were sown September 26. Each case was carried out in four series.

In winter, chopped straw was spread over all the cylinders for protection.

In spring, it became noticeable that the plants developed from inoculated seeds were of a fresher green color than those grown from the check seeds.

On May 8, the plants were cut and also the roots were isolated from the soil. The inoculated plants showed numerous nodules at the upper parts of the roots, while the check plants had comparatively few nodules.

The results were as follows (average of 4 cylinders):—

	No. of cylinders.	In the fresh state.			In the air-dry state.			Comparative yield.	
		Stems & leaves g	Roots g	Whole plant g	Stems & leaves g	Roots g	Whole plant g	Stems & leaves.	Whole plant.
I. No manure	a. original seed	1915.	267.9	2182.9	265.3	35.58	300.88	100	100
	b. inoculated seed	2089.	287.1	2376.1	302.0	41.46	343.46	114	<b>114</b>
II Phosphoric acid and potash	a. original seed	2029.	299.5	2328.5	277.5	37.63	315.13	105	105
	b. inoculated seed	2316.	292.3	2608.3	326.3	39.68	365.98	123	<b>122</b>

From the above figures we can decidedly conclude that the inoculated seeds invariably gave better results than the original seeds.

Moreover, as in Japan *Genge* is one of the most important green manures, it is of some interest to know the comparative yield in stems, leaves, and roots of this plant, hence I have carefully determined the respective harvests.

I. Air-dry matter of fresh leaves and stems :

Maximum ... ..	15.76 %
Minimum ... ..	12.80 „
Average of 16 cylinders ... ..	14.14 „

II. Air-dry matter of fresh roots :

Maximum ... ..	16.95 %
Minimum ... ..	10.89 „
Average of 16 cylinders ... ..	13.87 „

III. Ratio of Roots to the stems and leaves (in the air-dry state) :

Maximum ... ..	15.37 %
Minimum ... ..	11.53 „
Average of 16 cylinders ... ..	13.22 „

IV. Percentage of root in the entire plant :

Maximum ... ..	17.00 %
Minimum ... ..	10.30 „
Average ... ..	12.32 „

V. Proportion of the stems and the leaves in the total yield (excluding the roots) :

	Stems.	Leaves.
Maximum... ..	45.61 %	61.70 %
Minimum ... ..	38.30 „	54.39 „
Average ... ..	41.87 „	55.13 „

Also, the nitrogen content of the stems, the leaves, and the roots were determined.

In the air-dry state.	N
Stems ... ..	1.862 %
Leaves... ..	3.543 „
Roots ... ..	2.714 „

As to the manurial value of this plant, further studies are intended.



## On the Yield of *Polygonum Tinctorium* under Different Conditions.

BY

T. IMASEKI.

Since the indigo production from *Polygonum tinctorium* is of some importance in Japan, studies as to the yield of this plant under different manuring conditions seemed desirable. For this purpose, cultures in two different soils were made, their ratios of lime to magnesia were altered and the effect of calcium carbonate was compared with that of gypsum and air-slaked lime.

Soil A was a loamy humus soil derived from an un-manured field of our experimental farm. It contained in 100 parts of the fine-earth 1.08 % CaO and 0.78 % MgO soluble in concentrated hydrochloric acid. As the fine-earth amounted to 82.50% of the original soil, the latter contained 0.891% CaO and 0.619% MgO in an available form and the particles were of sufficiently small size.

Soil B was an alluvial sandy loam from Arakawa near Tokyo, containing in 100 parts of the air-dry fine-earth 0.925% CaO and 1.230% MgO, and as the fine-earth amounted to 82.52% of the original soil, the figures become 0.763% CaO and 1.015% MgO. Sixty pots served for this experiment. These pots held 7.5 kilo. of the soil A and 10.5 kilo. of the soil B, this difference being due to the former soil being much lighter than the latter.

In order to reach the intended ratios of CaO to MgO, the following additions were necessary :—

No. of pots.	Soil A.		Soil P.	
	Kind of special manures.	CaO : MgO	Kind of special manures.	CaO : MgO
I.	Original soil ... ..	1.44 : 1	Original soil ... ..	0.75 : 1
II.	" " + 43.1 gr. magnesite ...	1 : 1	" " + 50.6 gr. limestone ...	1 : 1
III.	" " + 50.1 gr. limestone ...	2 : 1	" " + 254.5 gr. " ...	2 : 1
IV.	" " + 139.1 gr. " ...	3 : 1	" " + 458.4 gr. " ...	3 : 1
V.	" " + 225.5 gr. gypsum ...	3 : 1	" " + 743.3 gr. gypsum ...	3 : 1
VI.	" " + 127.5 gr. precipitated CaCO <sub>3</sub>	3 : 1	" " + 420.4 gr. precipitated CaCO <sub>3</sub>	3 : 1
VII.	" " + 151.2 gr. air-slaked lime	3 : 1	" " + 392.8 gr. air-slaked lime	3 : 1
VIII.	" " + 75.6 gr. " " "	2.2 : 1	" " + 196.4 gr. " " "	1.88 : 1
IX.	" " + 37.8 gr. " " "	1.9 : 1	" " + 98.2 gr. " " "	1.31 : 1
X.	" " + 18.9 gr. " " "	1.6 : 1	" " + 49.1 gr. " " "	1.03 : 1

The general manure applied in the beginning of May was as follows :—

	Per pot.
Chili salt-peter <sup>1)</sup> ... ..	12 grams.
Monopotassium phosphate ... ..	7.5 "
Potassium sulphate ... ..	7.5 "

The seeds were sown May 5, and the leaves harvested July 9. After harvesting the first crop, each pot was freshly manured with 2 grams of sodium nitrate. The second crop was harvested August 3.

The amounts of the first and the second harvests are shown in the following tables (average of 3 pots) :—

2). One half of the dose was applied later, June 5.



## Soil A.

No. of pots.	Kind of special manures.	CaO/MgO	First crop (air-dry) g.		Second crop (air-dry) g.		Sum of the first and the second crops, g.		Comparative total yield of leaves.
			Leaves.	Stems.	Leaves.	Stems.	Leaves.	Stems.	
I	Original soil	1.44/1	5.83	2.63	5.24	5.89	11.07	8.52	100
II	Magnesite...	1/1	8.33	3.73	5.99	7.46	14.32	11.19	129
III	lime-tone ...	2/1	7.80	3.32	5.66	5.99	13.46	9.31	122
IV	" ...	3/1	6.79	3.43	5.77	5.54	12.56	8.97	114
V	Gypsum ...	3/1	8.19	3.83	7.03	7.94	15.22	11.77	137
VI	precipitated CaCO <sub>3</sub>	3/1	6.74	2.98	5.90	6.28	12.64	9.26	114
VII	air-slaked lime	3/1	6.42	2.87	6.24	7.11	12.66	9.98	114
VIII	" "	2.2/1	8.05	3.99	6.52	7.46	14.57	11.45	132
IX	" "	1.9/1	8.69	3.81	6.47	7.30	15.16	11.11	137
X	" "	1.6/1	9.06	4.92	6.48	7.26	15.54	12.18	140

## Soil B.

No. of pots.	Kind of special manures.	CaO/MgO	First crop (air-dry) g.		Second crop (air-dry) g.		Sum of the first and the second crops, g.		Comparative total yield of leaves.
			Leaves.	Stems.	Leaves.	Stems.	Leaves.	Stems.	
I	Original soil	0.75/1	6.07	3.55	4.67	5.29	10.74	8.84	100
II	limestone ...	1/1	8.05	3.80	5.80	6.14	13.85	9.94	129
III	" ...	2/1	7.48	3.18	6.48	6.17	13.96	9.35	130

No. of pots.	Kind of special manures.	CaO/MgO	First crop (air-dry) g.		Second crop (air-dry) g.		Sum of the first and the second crops, g.		Comparative total yield of leaves.
			Leaves.	Stems.	Leaves.	Stems.	Leaves.	Stems.	
IV	limestone ...	3/1	6.86	3.00	4.78	5.82	11.64	8.82	108
V	gypsum ...	3/1	8.07	3.57	5.92	5.67	13.99	9.24	130
VI	precipitated CaCO <sub>3</sub>	3/1	5.48	1.97	5.03	5.01	10.51	6.98	99
VII	air-slaked lime	3/1	5.62	2.31	5.03	6.08	10.65	8.39	98
VIII	" "	1.88/1	6.93	2.61	6.03	6.39	12.96	9.00	121
IX	" "	1.31/1	7.65	2.65	6.48	7.10	14.13	9.75	132
X	" "	1.03, 1	7.72	3.23	5.92	6.46	13.64	9.59	127

On glancing over the above tables, it will be noticed that *the ratio of lime to magnesia* in the soil has a considerable influence on the yield of *Polygonum tinctorium*, *the ratios 1 : 1 and 2 : 1 giving better results than 3 : 1, when lime is applied as carbonate or air-slaked lime*<sup>1)</sup>.

1). With gypsum, however, also the ratio 3 : 1 yielded good results, since the availability of it does not depend on the acidity of the rootlets, but only on its small solubility in water. Hence, an increase of lime in the form of gypsum will not lead to an increased absorption by the roots. Cf. O. Loew and K. Aso, Bul. Coll. of Agri., Tokyo, Vol. VI., No. 4.

## On the Most Favorable Ratio of Lime to Magnesia for the Mulberry Tree.

BY

M. NAKAMURA.

It has been shown by various experiments carried out at the College of Agriculture of the Tokyo Imperial University that a maximum harvest depends, other things being equal, upon a certain ratio of the amount of lime to magnesia available to the roots.

When both these bases are present in an equal degree of availability the most favorable ratio for cereals is  $\frac{\text{CaO}=1 \text{ to } 1.5}{\text{MgO}=1}$ , while plants with more abundant foliage require 2-4 times more lime than magnesia. Since the mulberry tree is one of the most important agricultural plants in Japan, the export of silk from here reaching a very high figure, it is of considerable value to determine the most favorable ratio of lime to magnesia for that plant. For the experiment served the sub-soil of Nishigahara which contains, according to a former determination, 0.24% CaO and 1.96% MgO soluble in hot hydrochloric acid. Ten zinc pots received 20 kilo. of soil each, while four other pots 60 kilo. each. This soil was sifted before use through a 3 mm. sieve. The general manure consisted, for each 10 kilo. of soil, of 10 g NaNO<sub>3</sub>, 5 g Amm. phosphate and 5 g KNO<sub>3</sub>. In order to provide the ratios of CaO : MgO to be tested the following additions were necessary —

- |              |  |  |   |
|--------------|--|--|---|
| (A) (3 pots) | $\frac{\text{CaO}}{\text{MgO}} = \frac{0.12}{1}$ | nearly.....Original soil               |   |
| (B) (3 pots) | $\frac{\text{CaO}}{\text{MgO}} = \frac{1}{1}$    | 172 g CaO = 307.14 g CaCO <sub>3</sub> | } |
| (C) (3 pots) | $\frac{\text{CaO}}{\text{MgO}} = \frac{2}{1}$    | 368 g CaO = 757.14 g CaCO <sub>3</sub> |   |
- for each 10 kilo.  
of soil,  
respectively.

(D) (3 pots)	$\frac{\text{CaO}}{\text{MgO}} = \frac{3}{1}$	564 g CaO = 1007 g CaCO <sub>3</sub>	} for each 10 kilo. of soil, respectively.
(E) (2 pots)	$\frac{\text{CaO}}{\text{MgO}} = \frac{4}{1}$	760 g CaO = 1395.7 g CaCO <sub>3</sub>	

On May 22, 1904, two young plants of the variety called *Roso* about 1 foot long were planted in each pot, and after a short time a selection was made, leaving one in each pot, all being now of nearly equal size. On May 27 the young branches were cut off. On June 7 new buds appeared in the pots (A) and (C) and on the 9th in other pots, while on the 12th young leaves had developed.

June 7.

	A			B			C			D			E	
	a	b	c	a	b	c	a	b	c	a	b	c	a	b
No. of buds ... ..	0	0	0	0	0	0	1	0	0	0	0	0	1	0

June 9.

	A			B			C			D			E	
	a	b	c	a	b	c	a	b	c	a	b	c	a	b
No. of buds ... ..	1	1	2	2	1	1	2	1	1	2	1	1	1	1
No. of leaves... ..	0	0	0	0	0	0	0	0	0	0	0	0	0	0

June 12

	A			B			C			D			E	
	a	b	c	a	b	c	a	b	c	a	b	c	a	b
No. of buds ... ..	1	2	2	2	2	1	2	1	1	2	1	2	2	1
No. of leaves... ..	1	2	1	2	4	0	3	2	2	2	2	3	3	2

June 20.

	A			B			C			D			E	
	a	b	c	a	b	c	a	b	c	a	b	c	a	b
No. of buds ... ..	1	2	2	2	2	1	2	1	1	2	1	2	2	1
No. of leaves... ..	5	6	3	4	6	2	6	5	4	4	4	5	5	4

June 30.

	A			B			C			D			E	
	a	b	c	a	b	c	a	b	c	a	b	c	a	b
No. of buds ... ..	1	2	2	2	2	1	2	1	1	2	1	2	2	1
No. of leaves... ..	8	8	6	11	9	6	9	7	6	10	7	11	7	6

July 15.

	A			B			C			D			E	
	a	b	c	a	b	c	a	b	c	a	b	c	a	b
Gight of trunk (cm.)	31.8	29.4	12.7	26.1	34.2	28.2	41.5	36.7	24.8	39.4	29.7	28.8	33.6	30.9
The average (cm.)	24.6			29.5			34.3			32.6			32.3	
No. of leaves	12	10	8	12	14	13	12	11	9	13	10	13	12	10
The average	10			13			11			12			11	

August 3.

	A			B			C			D			E	
	a	b	c	a	b	c	a	b	c	a	b	c	a	b
Gight of trunk (cm.)	45.5	38.2	14.2	36.1	51.5	37.9	59.4	53.9	30.3	59.4	39.4	45.5	37.3	58.2
The average (cm.)	32.6			41.8			47.9			48.1			47.5	
No. of leaves	19	12	9	14	18	20	23	20	13	21	15	17	15	19
The average	13			17			19			18			17	

## September 10.

	A			B			C			D			E	
	a	b	c	a	b	c	a	b	c	a	b	c	a	b
Hight of trunk (cm.)	63.6	54.5	23.6	58.2	85.8	69.7	79.7	90.0	81.2	73.6	88.5	91.5	80.9	88.8
The average (cm.)	47.2			71.2			83.6			84.5			84.9	
No. of leaves	23	19	20	34	35	28	77	33	37	35	56	37	55	29
The average	21			32			49			43			42	

## October 20.

	A			B			C			D			E	
	a	b	c	a	b	c	a	b	c	a	b	c	a	b
Hight of trunk (cm.)	66.4	61.2	24.2	67.3	93.9	78.8	83.3	100.3	87.9	79.4	100.5	118.2	90.9	109.1
The average (cm.)	50.6			85.0			95.5			99.4			100.0	
No. of leaves	23	22	25	38	53	34	83	38	46	43	66	46	62	35
The average	23			41			55			51			48	

Photographs were taken, October 25th, which are reproduced on Plate XXVI.

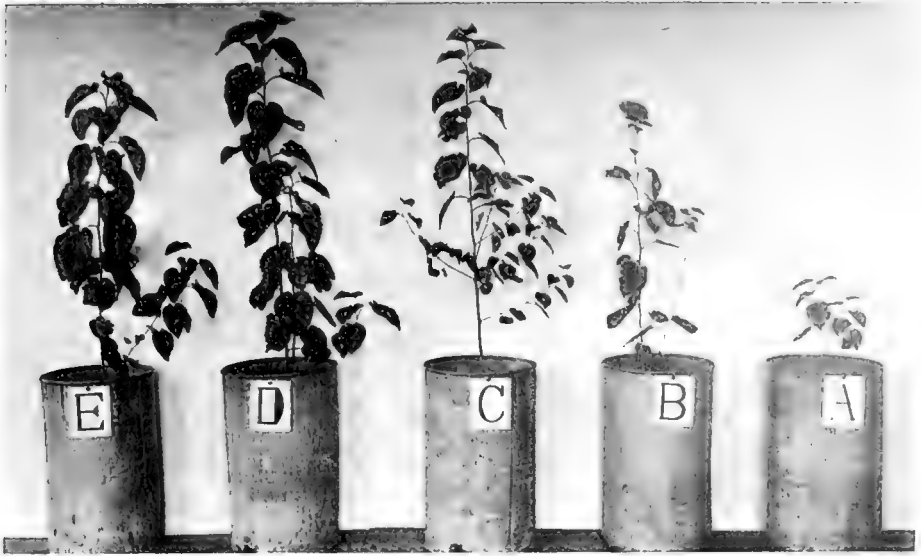
The following table shows the relative development of branches and number of leaves, the production on the original soil being assumed to be 100:

				Average length.	Average No. of leaves.
A)	Original soil	...	...	100	100
B)	$\frac{\text{CaO}}{\text{MgO}} = \frac{1}{1}$	...	...	158	178
C)	" = $\frac{2}{1}$	...	...	179	239
D)	" = $\frac{3}{1}$	...	...	196	222
E)	" = $\frac{4}{1}$	...	...	197.6	209

It will be noticed from the tables just described, that the plants in the pots D and E had the best development in regard to the height of the trunk. Regarding the number of leaves the plants in D were superior to those of E, these containing 3 leaves less. Both these sets of plants were surpassed by the plants in C as to the number of leaves, but in regard to green coloration and size of the leaves the plants D and E were superior to those of C. The result of this experiment, leaves no doubt that for the mulberry tree the best ratio  $\frac{\text{CaO}}{\text{MgO}} = \frac{3}{1}$  - i.e. the lime factor for the mulberry tree is = 3, which agrees very well with a former observation of Prof. Aso.







E.  
 $\frac{\text{CaO}}{\text{MgO}} = \frac{4}{1}$

D.  
 $\frac{\text{CaO}}{\text{MgO}} = \frac{3}{1}$

C.  
 $\frac{\text{CaO}}{\text{MgO}} = \frac{2}{1}$

B.  
 $\frac{\text{CaO}}{\text{MgO}} = \frac{1}{1}$

A.  
 Original  
 Soil.



## Are Soils Containing Less than 0.02 % SO<sub>3</sub> Benefited by Special Manuring with Sulphates?

BY

G. DAIKUHARA.

Soils containing less than 0.02 % SO<sub>3</sub> are rather frequent and since such soils occur in Japan, it has some value to decide whether sulphates would considerably increase the yields by furnishing easily assimilable sulphur for protein formation. I selected for my test three soils which gave the following numbers on analysis<sup>1)</sup>:

	CaO.	MgO.	P <sub>2</sub> O <sub>5</sub> .	SO <sub>3</sub> .
I.	1.153 %	0.092 %	0.025 %	0.016 %
II.	1.128 "	0.118 "	0.022 "	0.013 "
III.	0.013 "	0.035 "	0.017 "	0.010 "

No. I came from Sakamura in Hiroshima Prefecture and was a sandy loam; No. II came also from Heira-Mura in the same Prefecture and was a clayey soil; and No. III came from Hirono-Mura in Fukushima Prefecture and was also of a clayey nature.

Seventy-two zinc pots containing 13, 14 and 11 Kg soils resp. served for this experiment, three pots for each trial. The general manure per pot for these three soils was:

Sodium nitrate.....	6 g. in two fractions.
Double superphosphate.....	3 g
Potassium carbonate .....	2.5 g

1). The analysis was carried out according Ulbricht's method with a hydrochloric acid of 10 %, a little modified by T. Katayama.

2). Only the soluble portion of this preparation served for this experiment and contained 36.76 % P<sub>2</sub>O<sub>5</sub>, 0.81 % CaO and 0.83 % SO<sub>3</sub> in the original sample.

In every case also an experiment without general manure was made in order to observe principally the effects of the sulphates added on the condition of the soil, since, especially with clayey and humus soils, the effects on the soils have to be well distinguished from the effects on the plants. Gypsum, magnesium sulphate and sodium sulphate may be able to liberate potassa from hydrous silicates and render it more available to the plants.

With the soil No. I and No. III the lime content was larger than the magnesia content and since barley was to be grown the manuring with magnesia might benefit the barley. In these cases the sulphate was applied in the form of crystallized magnesium sulphate. Further for sake of comparison, magnesia was also applied as magnesite with and without sodium sulphate (equivalent to  $MgSO_4$ ).

In the case of the soil No. II there was more magnesia present than lime, hence the sulphate applied was  $CaSO_4 \cdot 2H_2O$ . Control pots contained either limestone or limestone and sodium sulphate. The following table will show the quantities applied per pot :

Kind of Manures.	Soil No. I.	Soil No. II.	Soil No. III.
$MgSO_4 \cdot 7H_2O$ ... ..	1.61 g <sup>1)</sup>	—	1.30 g <sup>1)</sup>
Magnesite ... ..	16.51 „	—	13.29 „
$CaSO_4 \cdot 2H_2O$ ... ..	—	9.68 g <sup>2)</sup>	—
$CaCO_3$ ... ..	—	16.88 „ <sup>2)</sup>	—
„ ... ..	—	22.50 „ <sup>3)</sup>	—
$Na_2SO_4 \cdot 10H_2O$ ... ..	2.11 g	18.13 „	1.70 g

Thirty-one seeds p. pot were sown Nov. 29, 1904 and the young plants of about 6 cm. height were reduced to 22, 17 and 21 resp. in the three different soils. The height of plants measured April 8 may be seen in the following table :

1). The  $MgO$  plied as sulphate corresponds to 1/30 of the calculated amount of  $MgO$  as magnesite.

2). These amounts were applied to the second series of soil No. II pot (2), 1/4 of the calculated amount of  $CaO$  being applied as  $CaSO_4 \cdot 2H_2O$  (cf. this Bulletin Vol. I, No. 1, p. 28).

3). This amount was applied to the third series of the soil II.

Soil No. I.

Kinds of manure.	A). Without general manure.		B). With general manure.	
	Height of plants.		Height of plants.	
	of each pot. cm.	average. cm.	of each pot. cm.	average. cm.
1) No special manure ... ..	a. 51.5 b. 56.5 c. 51.6	53.1	66.0 66.6 64.5	65.7
2) $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ ... ..	a. 49.2 b. 58.5 c. 48.0	51.9	69.0 67.5 63.6	66.7
3) Magnesite ... ..	a. 53.1 b. 53.1 c. 52.5	52.9	63.9 68.1 67.5	66.5
4) Magnesite + $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ .	a. 55.2 b. 52.5 c. 46.5	51.4	61.5 66.6 60.6	63.9

Soil No. II.

Kinds of manure.	A). Without general manure.		B). With general manure.	
	Height of plants.		Height of plants.	
	of each pot. cm.	average. cm.	of each pot. cm.	average. cm.
1) No special manure ... ..	a. 3.9 b. 4.5 c. 4.8	4.4	32.1 32.4 33.0	32.5
2) Gypsum + Lime-stone ... ..	a. 9.6 b. 9.9 c. 6.3	8.6	48.0 51.6 46.2	48.6

Kinds of manure.	A). Without general manure.		B). With general manure.		
	Height of plants.		Height of plants.		
	of each pot. cm.	average. cm.	of each pot. cm.	average. cm.	
3) Limestone ... ..	a.	11.1	} 12.0	51.0	} 51.0
	b.	11.4		52.5	
	c.	13.5		49.5	
4) Limestone + $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ .	a.	8.1	} 9.6	46.5	} 49.7
	b.	10.2		52.5	
	c.	10.5		50.1	

## Soil No. III.

Kinds of manure.	A). Without general manure.		B). With general manure.		
	Height of plants.		Height of plants.		
	of each pot. cm.	average. cm.	of each pot. cm.	average. cm.	
1) No special manure	a.	24.9	} 25.1	37.0	} 38.4
	b.	28.8		33.1	
	c.	21.0		25.3	
2) $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ ... ..	a.	24.6	} 23.9	62.1	} 51.6
	b.	22.5		57.0	
	c.	24.6		—	
3) Magnesite ... ..	a.	18.6	} 20.4	57.0	} 58.8
	b.	27.9		51.4	
	c.	23.7		60.0	
4) Magnesite + $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ .	a.	25.5	} 20.5	61.8	} 58.3
	b.	20.1		58.5	
	c.	17.9		54.0	

Plants were cut on June 10 and the harvest was weighed in the air-dry state with the following result :

No. I. Hiroshima soil (a).

(A.) Without general manure.

Kinds of manure.	No. of stalks.	Length of stalks cm.	Weight p. pot of				Average of	
			Grains g	Stalks g	Chaff g	Total g	Grains g	Total g
1) No special manure	a. 32	93.0	28.88	50.25	3.00	82.13		
	b. 39	97.8	25.50	59.25	2.63	87.38	26.91	85.54
	c. 33	94.5	26.36	49.13	2.63	78.12		
2) MgSO <sub>4</sub> ·7H <sub>2</sub> O.	a. 28	96.0	22.25	48.75	1.50	72.50		
	b. 22	96.0	16.58	35.63	1.13	53.34	21.13	66.51
	c. 25	88.2	24.75	40.50	2.63	73.88		
3) Magnesite ...	a. 26	88.2	22.25	46.88	2.63	69.76		
	b. 29	95.1	19.13	56.25	3.00	78.38	22.13	76.38
	c. 32	96.0	27.00	51.00	3.00	81.00		
4) Magnesite + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	a. 33	98.4	26.63	57.00	3.38	87.01		
	b. 29	98.1	24.75	53.25	3.38	81.38	27.63	86.51
	c. 35	92.0	31.50	55.50	4.13	91.13		

(B.) With general manure.

Kinds of manure.	No. of stalks.	Length of stalks cm.	Weight p. pot of				Average of	
			Grains g	Stalks g	Chaff g	Total g	Grains g	Total g
1) No special manure	a. 61	100.8	68.25	106.88	6.75	181.88		
	b. 61	114.0	63.38	104.25	6.38	174.01	64.75	176.13
	c. 64	111.0	62.63	104.63	5.25	172.51		
2) MgSO <sub>4</sub> ·7H <sub>2</sub> O.	a. 59	106.2	69.75	114.00	6.00	189.75		
	b. 59	112.5	60.75	106.50	5.25	172.50	66.63	181.00
	c. 61	101.4	69.38	105.38	6.00	180.76		

Kinds of manure.	No. of stalks.	Length of stalks cm.	Weight p. pot of				Average of		
			Grains g	Stalks g	Chaff g	Total g	Grains g	Total g	
3) Magnesite ...	a.	63	101.7	69.00	111.38	6.75	187.13		
	b.	60	105.6	68.25	111.00	7.13	186.38	69.13	187.13
	c.	64	108.1	70.13	111.38	6.38	187.89		
4) Magnesite + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	a.	66	109.5	59.25	100.13	5.63	165.01		
	b.	60	100.4	69.38	107.25	6.38	183.01	63.88	173.51
	c.	58	107.1	63.00	103.50	6.00	172.50		

## No. II. Hiroshima soil (b).

## (A). Without general manure.

Kinds of manure.	No. of stalks.	Length of stalks cm.	Weight p. pot of				Average of		
			Grains g	Stalks g	Chaff g	Total g	Grains g	Total g	
1) No special manure	a.	13	14.4	0	0.38	0	0.38		
	b.	15	17.1	0	0.75	0	0.75	0	2.00
	c.	16	17.4	0	4.88	0	4.88		
2) Gypsum + Limestone	a.	—	—	—	—	—	—		
	b.	18	27.3	0.15	3.00	0.05	3.20	0.27	4.51
	c.	18	26.4	0.38	2.63	0.18	5.81		
3) Limestone ...	a.	22	26.0	1.13	5.25	0.38	6.76		
	b.	21	33.3	1.13	4.88	0.38	6.39	1.13	6.64
	c.	19	36.2	1.13	5.25	0.38	6.76		
4) Limestone + Na <sub>2</sub> SO <sub>4</sub> ·10H <sub>2</sub> O	a.	14	32.1	0.38	4.13	0.18	4.69		
	b.	16	31.5	0.75	4.88	0.38	6.01	0.50	4.75
	c.	14	29.1	0.38	3.00	0.18	3.56		

1). Plants in this pot were attacked by fungus.



(B). With general manure.

Kinds of manure.	No. of stalks.	Length of stalks cm.	Weight p. pot of				Average of		
			Grains g	Stalks g	Chaff g	Total g	Grains g	Total g	
1) No special manure	a.	29	57.9	1.13	31.88	0.75	33.76	1.25	35.13
	b.	30	79.5	1.88	35.25	0.75	37.88		
	c.	32	60.6	0.75	32.63	0.38	33.76		
2) Gypsum + Limestone	a.	47	87.9	32.25	66.75	3.38	102.38	34.63	104.01
	b.	46	91.8	35.25	64.50	4.13	103.88		
	c.	42	87.0	36.38	64.50	4.88	105.76		
3) Limestone <sup>1)</sup> ...	a.	44	90.0	35.25	69.38	3.38	108.01	38.63	112.51
	b.	45	99.0	36.75	67.50	4.50	108.75		
	c.	46	94.2	43.88	70.88	6.00	120.76		
4) Limestone + $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$	a.	44	93.0	31.50	62.25	4.13	97.88	41.63	116.38
	b.	55	94.5	48.75	76.50	5.25	130.50		
	c.	49	90.0	44.63	71.25	4.88	120.76		

No. III. Fukushima soil.

(A). Without general manure.

Kinds of manure.	No. of stalks.	Length of stalks cm.	Weight p. pot of				Average of		
			Grains g	Stalks g	Chaff g	Total g	Grains g	Total g	
1) No special manure	a.	22	57.0	10.13	14.63	1.50	26.26	10.00	26.38
	b.	21	59.4	10.13	15.75	1.50	27.38		
	c.	21	62.1	9.75	14.25	1.50	25.50		
2) $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ ...	a.	21	56.4	7.88	13.88	1.13	22.89	7.75	24.26
	b.	22	57.9	8.63	15.38	1.50	25.51		
	c.	24	46.5	6.75	16.13	1.50	24.38		

1). A part of this increase by limestone may be due to the improvement of the mechanical condition of the clay soil. Further communication on this effect will follow later on.

Kinds of manure.	No. of stalks.	Length of stalks cm.	Weight p. pot of				Average of		
			Grains g	Stalks g	Chaff g	Total g	Grains g	Total g	
3) Magnesite	a.	18	56.4	7.13	12.75	1.50	21.38		
	b.	23	60.0	10.50	15.00	1.13	26.63	8.25	23.70
	c.	21	57.3	7.13	14.63	1.50	23.26		
4) Magnesite + $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$	a.	21	66.9	11.63	16.88	1.50	32.01		
	b.	21	58.5	9.75	15.38	3.38	28.51	10.13	28.01
	c.	21	57.6	9.00	15.00	1.50	25.50		

## (B). With general manure.

Kinds of manure.	No. of stalks.	Length of stalks cm.	Weight p. pot of				Average of		
			Grains g	Stalks g	Chaff g	Total g	Grains g	Total g	
1) No special manure	a.	57	97.2	57.00	97.88	7.13	126.01		
	b.	58	97.5	52.13	85.50	4.88	142.51	52.75	138.26
	c.	61	95.4	49.13	95.25	4.88	149.26		
2) $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	a.	65	95.1	48.38	95.25	5.25	148.88		
	b.	60	93.0	52.50	91.50	5.25	149.25	50.44	149.07
	c. <sup>1)</sup>	—	—	—	—	—	—		
3) Magnesite	a.	62	87.0	53.63	91.88	6.38	151.89		
	b.	60	90.0	45.38	94.88	5.25	145.51	47.50	147.26
	c.	56	97.5	43.50	95.63	5.25	144.38		
4) Magnesite + ... $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$	a.	73	95.4	49.13	99.75	7.88	156.76		
	b.	64	97.5	52.25	87.00	6.38	143.63	49.50	146.76
	c.	58	99.0	49.13	86.25	4.50	139.88		

1). The plants in this pot were damaged by fungus.

From these results we conclude :

- 1). An amount less than 0.02 %  $\text{SO}_3$  in the three soils was quite sufficient to meet the requirements of the barley plants for sulphur. The difference in the harvests was too small to admit any other conclusion than this.
- 2). In the soil No. I and No. III the manuring with magnesia had no decisive effect ; this may have been due to the small differences of lime and magnesia contents in these soils.
- 3). Soil No. II<sup>1)</sup> showed a very unfavorable mechanical condition being a very stiff clay and was probably very poor in potassa<sup>2)</sup>, while the amount of  $\text{P}_2\text{O}_5$  was only 0.022%. Hence the addition of limestone to the un-manured soil had very little effect although the mechanical condition was improved, while with the manured soil the addition of limestone produced a surprising increase of barley grains from 1.25 g to 38.63 g.

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1). This soil was found afterwards to have a strong acid reaction on litmus, and since this soil contains only a little humus, the acidity would probably be due to acid silicates. Enormous increase of harvest by liming of this soil is therefore partly explained by the neutralization of the acidity. Many such acid soils occur in Japan and the result of investigation of these soils will be published later on.

- 2). A sample of soil taken from the same area contained only 0.088%  $\text{K}_2\text{O}$ .



## Chemical Composition of Tea Leaves at Various Stages of Development.

BY

S. SAWAMURA.

Tea prepared from very young leaves is of the best quality. But as the produce is not large tea is prepared in most parts from pretty well developed leaves. Therefore there may be species of tea prepared from the leaves varying from very young to very old. It is of some interest to know the relation of the development of tea leaves to their chemical composition. The relation of the development of vegetable leaves to their chemical composition has not hitherto been much studied. Höhnel<sup>1)</sup> found, by investigating the relation between the water content and the development of leaves with 40 species of plants, that the water contents of leaves represents the maximum in the youngest stage of development. Fliche and Grandeau<sup>2)</sup> found that with *Robinia pseudacacia*, *Cerasus avium*, *Castanea vulgaris* and *Betula alba*, the leaves became richer in ashes but poorer in water and nitrogen as they grew older. Kellner<sup>3)</sup> gathered tea leaves twice a month from May to November and found that as the leaves grew older the water content decreased from 76.83% to 60.97%, and in dry matters crude protein decreased from 30.64% to 17.14%; theine from 2.85% to 1.00%; but ether extract increased from 6.48% to 22.19%; crude fiber from 9.10% to 18.34%; tannin from 8.53% to 12.16% and ashes from 4.69% to 5.04%.

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- 1). Centralblatt für Agrikulturchemie 1878, p. 911.
  - 2). Centralblatt für Agrikulturchemie 1877, p. 43.
  - 3). Landw. Versuchstationen Vol. 39.

The variation of chemical composition of tea leaves during a year was made clear by this investigation, but the variation during tea manufacturing period is still unknown. The writer therefore has undertaken to investigate this point. For this investigation it was not desirable to compare tea leaves picked at various stages of development in different periods, because there might be some disturbance resulting from climatical influences. Therefore in this investigation variously developed leaves of the young twigs bearing four leaves, the top one of which was of course in a folded state, were picked as is usual in tea harvest and analyzed. Crude protein was estimated by multiplying with 6.25 nitrogen found by Kjeldahl's method after reducing theine-nitrogen. Albuminoid-nitrogen was estimated by Stutzer's method; ether extract by reducing theine from that obtained by Soxhlet's method; crude fiber by Weende method; tannin by improved Loewenthal's method calculating 63 gr. oxalic acid=38.3 gr. tannin; and theine by extracting the residue obtained by evaporating tea decoction with magnesia with ether.

The average length of the leaves and young twigs bearing them were as follows :—

First leaves	not observed
Second „	3.58 cm.
Third „	3.32
Fourth „	3.82
Twigs	4.32

The proportion of the weight of the leaves and young twigs was as follows :—

	Fresh state.	Dry state.
First leaves	100	100
Second „	203	208
Third „	412	399
Fourth „	577	534
Twigs	717	419

Chemical composition was as follows :—

In 100 parts of fresh substance.

	Leaves.				Twigs.
	1	2	3	4	
Water ... ..	72.476	71.979	73.280	74.540	83.911

In 100 parts of solid matters.

	Leaves.				Twigs.	
	1	2	3	4		
Crude protein ... ..	41.238	42.044	34.016	30.153	28.400	
Ether extract ... ..	6.981	7.903	11.354	11.428	8.027	
N-free extract ... ..	18.397	13.651	18.499	20.728	26.957	
Crude fiber ... ..	10.872	10.895	12.253	14.748	17.079	
Theine ... ..	3.578	3.559	3.232	2.570	2.146	
Tannin ... ..	13.965	16.960	15.779	15.438	11.140	
Ashes (free from C) ..	4.969	4.988	4.867	4.935	6.249	
Total N ... ..	7.545	6.727	6.294	5.504	5.112	
Albuminoid N ... ..	6.136	5.414	5.056	4.298	3.296	
Theine N... ..	0.947	0.939	0.855	0.680	0.568	
Soluble {	organic matter ... ..	45.929	48.255	46.957	45.460	44.063
	inorganic matter ...	4.162	4.097	4.296	3.124	5.680

From these results we conclude that with the development of the tea leaves, water, crude protein and theine decrease, while ether extract, crude fiber and tannin increase. Solubility shows no regular variation with the development of the tea leaves.

The writer express his sincere thanks to Mr. T. Oshima who analyzed these samples of tea leaves.





## On the Aroma of Black Tea.

BY

T. KATAYAMA.

It is of great importance for the manufacture of black tea, to know by what agencies its agreeable aroma is produced. The so-called fermentation of tea is attributed by some authors to microbes by others however to the enzymes of the leaves. Bamber<sup>1)</sup> denies the existence of a genuine fermentation having been unable to observe any microbe. Newton<sup>2)</sup> supposes that the flavour of black tea is dependent upon the action of an oxidizing enzym in the tea leaf, but Crole<sup>3)</sup> and other authors ascribe the fermentation at least partly to the action of certain micro-organisms<sup>4)</sup>.

Since I had observed frequently bacilli on the rolled tea leaves undergoing the fermenting process, I was led to suppose that some relations between these bacilli and chemical changes in the tea leaf might exist. Hence I tried to kill the ordinary microbes adhering to the leaves and to infect the leaves with bacilli taken from *fermenting* leaves.

Fresh tea leaves were left in ether for 4 hours, rolled and dried as usual. The green color of these leaves not only gradually changed to brownish but also the characteristic aroma of black tea was observed after 10 hours, in spite of the odor of adhering traces of ether.

This experiment shows that the aroma is not caused by any micro-

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1). Agriculture and chemistry of tea.

2). On tea, a publication from India.

3). Tea, its cultivation and manufacture.

4). Aso has observed that the black color of tea is caused by the action of the oxidase of the leaves upon the tannin present (Bul. College of Agriculture, Tokyo Imp. Univ., Vol. IV, No. 4).

organisms. The same result was obtained when the ether was substituted by alcohol and chloroform.

Also powerful antiseptics as cresol, mercuric chloride were tried. Fresh tea leaves were soaked in a 4% cresol solution for 24 hours washed once with distilled water, dried in the sun and then rolled and kept compactly in a flask. The tea leaves changed gradually in color to brownish black and after 15 hours produced a distinct aroma modified however by the odor of traces of cresol remaining.

Fresh tea leaves were left in a 1%  $\text{HgCl}_2$  solution for 20 hours, whereby the leaves assumed a pale appearance, and washed with distilled water. When kept in a flask, the characteristic aroma of black tea was also here observed after some time, but the blackening of the leaves was here not observed.

When the so-called fermentation process is allowed to go on for too long a time before drying or firing, the normal aroma produced, gradually disappears and a sour smell develops. Finally white mould appears on the leaves. However if the leaf is treated with antiseptics as above mentioned, the sour smell is not observed.

These tests render it very probable that the development of aroma is due to the action of certain enzymes originally present in the leaves which produce the specific volatile oil of tea from certain compounds. This is in analogy to the flavour of tobacco which is also produced by the action of enzymes (oxidases).

I have further observed that after treating tea leaves with cyanogen gas for 5 hours the aroma fails to appear.

When tea leaves are repeatedly treated with ether or alcohol, the aroma fails to develop which shows that those substances which yield the aroma have been extracted by ether and alcohol, which agrees with observations of Kozai<sup>1)</sup>.

Since Kozai, Bamber and other authors observed that black tea can not be manufactured from steamed tea leaves, I have tried the influence of

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1). Bulletin College of Agriculture, Tokyo Imp. Univ., Vol. I, No. 7.

various lower temperatures. The tea leaves were kept at these temperatures for an hour and after having gone through the usual process the results were as follows :

40°C	...	...	...	...	...	...	...	...	good aroma.
50 "	...	...	...	...	...	...	...	...	" "
60 "	...	...	...	...	...	...	...	...	only a very weak aroma.
65 "	...	...	...	...	...	...	...	...	no aroma, only a raw grassy smell.
75 "	...	...	...	...	...	...	...	...	" " " " " " "
100 "	...	...	...	...	...	...	...	...	" " " " " " "

This result supports my opinion, that the production of aroma is caused by a certain enzyme. As to oxidizing enzymes their presence can easily be demonstrated. When tea leaves are treated with strong alcohol until the tannin is entirely removed, and then treated with distilled water, the aqueous extract thus obtained behaves as follows :

					Guaiac tincture.	Guaiac + H <sub>2</sub> O <sub>2</sub> .
40	...	...	(aroma)	...	blue	deep blue
50	...	...	( " )	...	"	" "
60	...	...	(very weak)	...	"	" "
65	...	...	(no aroma)	...	"	" "
75	...	...	( " " )	...	no coloration	no coloration
100	...	...	( " " )	...	" "	" "

Since the leaves kept at 65° developed no aroma but gave still the reactions for oxidase and peroxidase, it appears that other enzymes than these are concerned in the production of aroma.

POST SCRIPTUM.

As Mr. Katayama having had to break off his studies on account of his departure for India and Europe, Prof. SAWAMURA made a further experiment upon which he reports as follows :

"I extracted 156 g of fresh tea leaves with 900 c.c. of absolute alcohol and 147 g with 1 litre of 20% alcohol. The former extract was evaporated to dryness and the residue dissolved in water (A). The latter extract was precipitated with ether-alcohol (B). By adding the precipitate B

containing the enzymes to the solution (A), an agreeable aroma characteristic for the prepared tea was produced."

This result is a further confirmation of the view, that the tea aroma is caused by the original enzymes of the leaves. But the true nature of the enzymatic process requires further study. The most probable supposition is, however, that a peculiar enzym splits a certain glycoside present in small quantities and that one constituent thus liberated yields by taking up oxygen the aroma of tea.

Y. KOZAI.

# A Disease of the Japanese Ginseng Caused by *Phytophthora Cactorum* (Con. et Leb.) Schröt.

BY

S. HORI.

The Japanese ginseng (*Aralia quinquefolia* A. Gr. var. *Ginseng* Rgl. et Mack.) is at present chiefly cultivated in the northern part of this country : viz.—Fukushima, Nagano, Yamagata, Tochigi, Tottori, Shimane, and Hokkaido. The Dist. Shimane forms the southern limit of the ginseng culture and is celebrated for a superior article.

In the beginning of the summer of 1904, samples of the diseased ginseng plant were forwarded by Mr. S. Ema, the director of the Shimane Experiment Station to our Station for examination. Microscopic examination revealed the presence of the well known parasitic fungus *Phytophthora Cactorum* (Cohn et Lebert) Schröter by which the disease is evidently caused.

The disease is called locally *Koshi-ore* (bending at the loins) or *Koshi-nac* (paralyzing at the loins) according to the symptoms. It is said that the disease occurs more or less in the rainy season when the moist, warm weather has continued for some time. It was further reported that the disease was unusually destructive in May 1904, the damages being estimated to be about fifty thousand Yen (§ 25,000) in the limit of a small ginseng region of the Prov. Idzumo, Dist. Shimane.

I visited the Idzumo ginseng region at the end of March 1905, though the time was too early for the observation of the disease, because the ginseng plants had not yet come up above the ground. I recommended the growers to try the spraying of Bordeaux mixture, the first time, as soon as the leaves unfolded, and if it becomes necessary on account of the weather, the second spraying about two weeks later.

Two months afterwards, I received the reports, forwarded by friends

in the Idzumo ginseng region, that the disease had broken out towards the 24th of April and the spraying of the Bordeaux mixture was very effective as it thoroughly stopped the spreading of the disease.

When I was studying the ginseng disease in the spring of 1905, I requested Prof. J. M. Van Hook, Wooster, Ohio, to send me his publication on diseases of ginseng and at the same time I sent to him a sample of the diseased ginseng which was forwarded by Mr. S. Ema, who collected it in Idzumo in May 1904. Soon afterwards he kindly furnished me his work together with the following very interesting information under the date of May 16, 1905. Prof. Van Hook writes :

“I am in receipt of yours of April 17th inclosing specimen of ginseng. Permit me to thank you for the same. It was something I had never seen before. However a very strange coincidence occurred in regard to that disease. In the same mail in which your plant came, was a package from Sewisburg, Ohio containing diseased ginseng. I had just read your letter and examined the specimen you sent affected with *Phytophthora Cactorum*. Noticing that the plants looked similar to the one you sent, I remarked to Prof. Selby “That looks like Mr. Hori’s *Phytophthora*, doesn’t it?” Well, a microscopic examination revealed the disease due to *Phytophthora Cactorum*. Spores measured  $30-42=40-58 \mu$ . The man who sent us this material seems to think that it also killed his tobacco seedlings. We are now making a thorough investigation of the disease. It seems strange that this disease should never before have appeared here on ginseng, and then to make its appearance on exactly the day I received your letter. If your bulletin has not yet gone to press, you can add Ohio to the list of places in which it occurs on ginseng.”

According to the opinion of the ginseng growers, it seems credible that the ginseng mildew had existed in the Prov. of Idzumo a long time ago, though there were some fluctuations of the outbreak, and it has been hitherto completely overlooked until 1904 when I investigated the nature of the disease. Until then there was no reliable record of the occurrence of *Phytophthora Cactorum* on ginseng either in Japan or in other countries.

According to the information of Prof. Van Hook just mentioned, *Phytophthora Cactorum* occurs also on American ginseng at Sewisburg, Ohio, where it was observed just one year after the discovery of the above fungus on Japanese ginseng. In connection with the above fact, another strange coincidence may be recalled, namely that the "cucumber downy mildew," which was first discovered by the late N. Tanaka in the vicinity of Tokio in July 1888, was discovered just one year later by Prof. Halsted in New Brunswik, New Jersey in May 1889.

#### HISTORY OF THE GINSENG DISEASE.

Frank<sup>1</sup> was the first to describe a fungus on dying stems of *Panax quinquefolia*. The fungus was *Diplodia panacis* (Fr.) Cook, and entirely different from our fungus here mentioned. Prof. H. Garman<sup>2</sup> has noticed only that a rot destroys the wild root sometimes, without describing the fungus.

In 1900, Mr. T. Hanai<sup>3</sup> gave a short description on ginseng diseases "Koshi-nae," "root-rot" and "red-rot" in his report of our Exp. Station. His description of "Koshi-nae" disease is as follows :

"It is a dreadful disease for the growers, the leaves and stems shrivel first, are then discolored and finally rot spreads down to the root. The disease is caused by some parasitic fungus and from its rapid infectious nature, it spreads quickly. When the leaves or stems are affected by the disease, the exposure of the upper portion of the root to the air is very advisable, otherwise the rotting would proceed to the root itself."

In 1903 Prof. G. C. Butz<sup>4</sup> also gave a short note on a disease of the American ginseng as follows :

"The most serious loss may be caused by a fungus or several fungi usually present in wood soils. In consequence, a disease known as the "damping off" of seedlings and cuttings sometimes speedily attacks young ginseng plants at the surface of the soil, causing the stem to become soft and shrivel in a very short time. This disease

was found in some ginseng seedlings sent by Mr. N. B. Curstead, Olyphant Furace, Pa., in 1898. This fungus extends rapidly from plant to plant when they stand closely and in a single night may mow down an area of two or more square feet."

In 1904 Prof. Van Hook<sup>5</sup> published his work on the diseases of ginseng, in which he described and fully illustrated the "wilt disease" by the attack of *Acrostalagmus albus* Pr. and the "damping off" of seedlings by *Rhizoctonia* sp. Shortly afterwards he found one root-rot disease which he discovered was due to a fungus known as *Thielavia basicola* Zopf, and which he described and illustrated in Bulletin No. 156 of the Ohio Station.

So far as I know aside from his works nothing has ever been published in regard to a scientific investigation of ginseng disease.

Let us turn now to the brief history of *Phytophthora Cactorum* (Cohn et Lebert) Schröter.

In 1870 Cohn and Lebert<sup>6</sup> discovered this fungus occurring on Cactus stems, and named it *Peronospora Cactorum*. As it attacks many different plants, it was found and described as a new species respectively by different authors. Schrenk<sup>7</sup> found it on *Sempervivum* and gave the name *P. Sempervivi*. Hartig<sup>8</sup> has investigated this fungus more especially as a parasite attacking beech seedlings and gave the name *P. Fagi*. Shortly afterwards De Bary<sup>9</sup> observed the development of this fungus growing on cultivated *Sempervivum* and *Clarkia elegans* and changed the name to *Phytophthora omnivora*. Finally Schröter<sup>10</sup> changed the name more properly to *Ph. Cactorum* according to the priority of Cohn and Lebert.

As host plants Saccardo<sup>11</sup> has recorded only certain kinds of Cactus, A. Fischer<sup>12</sup>, however, gives about 23 species of different plants.

Berlese<sup>13</sup> has enumerated the following 28 species of plants as the host of *Ph. Cactorum*:

Hab. in foliis plantarum variarum e gr. Cleomes violaceae, Fagopyri tartarici, F. marginati, Clarkiae eregantis, Schizanthi pinnati, Alonsoae caulialatae, et in plantulis (praecique in cotyledonis) Oenotherae biennis, Lepidii sativi, Salpiglossi sinuati, Epilobii rosei, vel in plantis carnisos in primis Cereo giganteo, C. speciosissimo, C. peruviano, Sempervivo



alvido, *S. glauco*, *S. stenopetalo*, *S. tectorum*, *Melocacto nigro-*  
*mentosus*, vel demum in cotyledonis plantularum arborescentium non-  
nullarum et precipue *Fagi silvaticae*, *Aceris platanoidis*, *A. pseudo-*  
*platani*, *Fraxini excelsioris*, *Robiniae Pseudoacaciae*, *Pini silvestris*,  
*P. Laricio*, *P. Strobi*, *Laricis europeae*, *Abietis pectinatae* etc. in  
Germania et in Italia.

Some years ago Prof. Masee<sup>14</sup> noticed that this fungus also attacks the  
cocoa pods in Trinidad and Ceylon.

The occurrence, however, of *Phytophthora Cactorium* on ginseng plants  
had thus far not yet been recorded.

#### SYMPTOMS OF THE DISEASE.

The disease is favored very much by continuous wet and warm weather  
at the time of the opening of the leaves and spreads destructively especially  
after a strong storm. The outbreak of the disease in 1904 and 1905 in  
Idzumo ginseng region clearly illustrates this fact. During the middle and  
latter part of April in 1904, the weather was damp and rainy. On the 27th  
and 28th an outbreak of the disease was noticed in some fields, but suddenly  
it became severe throughout the fields in the ginseng region 5 or 6 days  
after a strong storm with heavy rainfall on the 1st and 2nd of May. Just  
at this time the ginseng plants were opening their tender leaves, which  
suffered much mechanical injury by the storm and were thoroughly soaked  
by the rain, though the plants were sheltered by a straw-thatched roof  
inclining toward one side, and were surrounded by a straw fence on three  
sides, the north side being left open. In 1905, the weather in the middle  
of April having been also moist, a slight outbreak of the disease was noticed  
at that time in some fields. But one week after a strong storm raging from  
the 20th to the 22nd, it developed violently throughout the ginseng  
region. At the time of this last storm the ginseng leaves had not yet  
opened, mechanical injuries to the leaves therefore were somewhat lighter  
than in the previous year, while the young stems were considerably injured  
by the violent motions. In fact, the disease attacks the plants only in their

young stage but not after the attainment of full growth even when the conditions of the weather are favorable for the development of the fungus.

The most characteristic symptom of the disease is the wilting of the leaves, as the water supply is stopped. But close observation shows that pale colored spots first appear on the blades, petioles and on certain portions of the stem, and more occasionally on the attaching point of the leaves or leaflets to the axis before the leaves entirely shrivel. The spots soon enlarge and show a softening of these attacked tissues within a few days. Since this decaying process proceeds downward to the roots, the entire plant begins to wilt and drops to the ground. When the spots on the blades however stop their spreading under certain conditions unfavorable to the fungus, they assume a light yellowish color with irregularly rounded contour, and persist in this state for a long time. Occasionally a *Fusarium* mould begins to grow on the axial part of the attacked leaves and on the surface of the certain portions of the stem a white or light rose colored appearance is produced

Ryzomes 1-2 years old are much less damaged than when 3-5 years old; the liability to attack increases with age. According to the information of Mr. Ema, the plants grown on well manured fields are also easily damaged.

#### CAUSE OF THE DISEASE.

As already stated, the disease is caused by the well known parasitic fungus *Phytophthora Cactorum* (Cohn et Libert) Schröter whose life history and infectious nature have been carefully studied by De Bary, Hartig and others. But that the ginseng plants also can form a host for this fungus is entirely new.

The fungus appears as a very delicate thin white mould almost insignificantly on the surface of the attacked plants. The conidiophores are simple, slender, delicate, colorless,  $95\mu$  in height,  $7\mu$  in diameter at broadest part, projecting out singly through the stomata or epidermis; branched ones are not found among my specimens. The spores are elliptical or ovate attaining the size of  $30-50=50-60\mu$ , sometimes much larger and of abnormal form

29=85.5 $\mu$ , and are attached singly at the broad end to the conidiophore which soon liberates the spore when matured. The latter is thin walled, contents colorless, fine granular with some small oil globules; papillated at the apex and showing a small projection at the base by which the conidiophore is attached. The spore germinates under proper conditions of moisture and gives rise to a number of zoospores. The oospores are produced in the tissues of the diseased plants. They are spherical in form, 26-28 $\mu$  in diameter, light brownish, thick walled; contents colorless, fine granular with some oil globules, loosely surrounded by the oogonium wall. Thus the form, size and other characters of the fungus essentially agree with the species observed in Europe.

When the spores transported by wind settle accidentally on the surface of a young ginseng plant, they rapidly germinate under favorable conditions to zoospores, and thus create a new center of disease. Although the conidiospores produced on a diseased plant are but few, yet since each individual spore gives rise to a large number of zoospores by germination, extensive fields of the ginseng plant are deadly infested by this disease within a few days. As already mentioned, the spread of the disease is much increased by strong storms with heavy rain fall. The fact that the disease develops principally at the point of the leaf axis, clearly shows that this particular spot is much suited for holding the spores which may be carried there by winds or washed down from the surface of the leaves by rain.

As the disease always occurs on young leaves, it seems that the full grown tissues resist the fungus though the weather may be favorable for its development.

The rotting of the diseased plants seems to be accelerated by the combined action of other fungi and bacteria which act as secondary parasites.

There exist several other diseases of ginseng caused by different fungi and bacteria a report on which will be given later.

## PREVENTION.

Though the growers of ginseng suffer annually great loss, they do not take any effective measures to prevent the disease. The only step is that they remove some soil from the upper part of the roots in the opinion that the rotting process would not spread to the roots.

I have proposed to the growers to spray with Bordeaux mixture at the proper season, and indeed this treatment was a great success. The proposed Bordeaux mixture consisted of:

Copper sulphate	...	...	...	...	...	1 pound.
Quick lime	...	...	...	...	...	1 pound.
Water	...	...	...	...	...	10 gallons.

Some growers sprayed 4 or 5 times, but experience showed that 2-3 times spraying suffices. Since the plants are sheltered by a roof and fences the sprayed mixture adheres to the plants for a long time without being washed off by rains, only heavy storms would render an additional spraying, necessary. My advise was as follows:

Spray Bordeaux mixture at least 10 days before the leaves open and apply a second dose at just the time when they open. The third spraying depends upon the conditions of the weather; about 10 days after the second spraying will be convenient.

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## Explanation of figures.

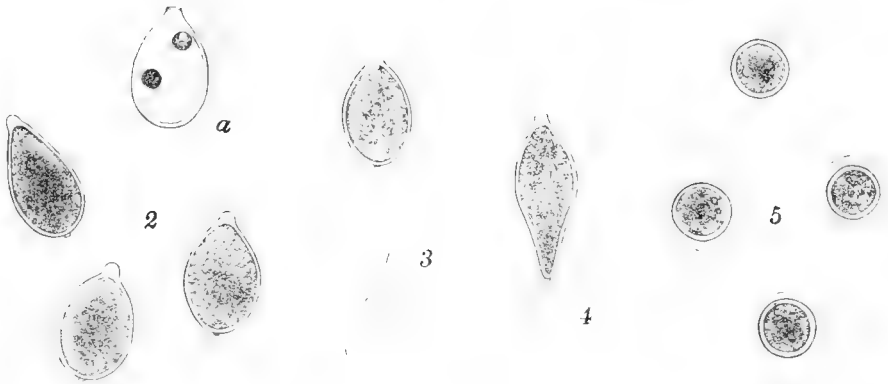
## PLATE XXVII.

- Fig. 1. Photograph of a diseased ginseng plant slightly reduced,  $\alpha$  directly attacked part, showing the white moulded and shrivelled tissue.
- Fig. 2. Spores of *Phytophthora Cactorum*. a. A germinated spore containing 2 zoospores. (Zeiss 4  $\times$  DD.)
- Fig. 3. Spore attached to the conidiophore. (Zeiss 4  $\times$  DD.)
- Fig. 4. Abnormal spore. (Zeiss 4  $\times$  DD.)
- Fig. 4. Oospores. (Zeiss 4  $\times$  DD.)
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*a*

*l*







# Seed Infection by Smut Fungi of Cereals.

BY

S. HORI.

By what manner smut fungi gain access to their respective host plants has been carefully studied by Kühn, Wolf and especially by Brefeld, but some points regarding the modes of natural infection are not yet fully understood. The present knowledge concerning the modes of natural infection by various smuts of cereals may be summarized as follows :

1. *Soil infection* : smut spores which found their way into the ground, infest the young sprouts or seedlings of the host.

2. *Flower infection* : smut spores after being carried into the flowers of the host by wind, germinate and remain as mycoplasma in the inside of the seed.

3. *Wind infection* : certain smut spores or sporidia will develop not only in flowers but also on any young tissue of the plant to which they had been carried by wind.

4. *Seed infection* : Such kinds of smut spores which cannot be easily scattered by wind or rain, may become attached to the seed coat during thrashing.

In order to observe whether spores in the soil infest the host, I have tried many experiments during the last 5 years. The smut fungi, the spores of which were used for soil infection, were *Ustilago Tritici*, *U. Hordei*, *U. nuda*, *U. Sorghi*, *U. Reiliana*, *U. Crameri*, *U. Panici-miliacei*, *U. Maydis*, *Urocystis occulta* and *Tilletia laevis*. After thoroughly mixing these with the soil, seeds of the respective host plants were sown in different intervals partly on the same day, partly after 5 or 10 days. But the results were always negative and no difference with the control plants was noticed.

By these experiments it became clear that the spores in the soil do not infest the host plants, and if such a case should happen, it would be a very rare one, at least in Japan.

While I was writing this article, Brefeld's Brandpilze IV reached us in which he also reports negative results of 3 years experiments (1903-1905) in the infection of several substrata (fresh horse dung or barnyard manure mixed with soil) with the spores of wheat and barley smut. His most recent experiments show that his former opinion of an increase of the smut disease by the application of fresh horse dung is erroneous. This agrees also with my experience in Japan. It is true that the most Japanese farmers do not use fresh horse dung for wheat and barley. They use fish guano, human excreta, rice bran, and to some extent compost manure containing rice straw. Yet the damage by smut may often amount to a loss of 10-20%.

Wheat and barley are sown in Japan in October-November and harvested in the following May or June. It is a peculiar phenomenon that if the seeds are sown early in the season the smut proportionally increases and *vic. versa*; this fact has been experimentally proved already. In consequence, the smut is comparatively rare on wheat and barley cultivated in the rice field, because the labour of harvesting rice, draining, plowing and drilling delays the sowing at least 1 to 1½ months. That fact is undoubtedly due to the difference between the germinating temperature of the smut spore and that of the seeds. Though the seeds are sown late in November, yet they germinate, but for germination of the smut spores adhering to the seed coat or the development of smut germs in the seed, the soil temperature is already too low.

The fact that the occurrence of the smut relatively decreases as the time of sowing becomes later and that there is no such tendency observed in summer wheat and barley, proves that the smut spores in the soil remain in an inactive condition.

Another very interesting fact, which clearly proves that the spores of smut fungi present in the soil are not the active source of the natural infection, was observed some years ago with the smut of Italian millet and sorghum in the field of our Experiment Station. The seeds of the last

mentioned plants were introduced directly from Manchuria in 1890 and in 1904, and were sown in the field of the Station. In the autumn of the respective year, about 50% of Italian millet and 10% of sorghum were smutted. Since the smut of Italian millet (*Ustilago Crameri*) is in Japan very rare and only known in a limited area in the province of Shinano, and since the smut of sorghum (*U. Sorghi*) is still rarer and as I had not yet observed the smut on Japanese sorghum, I concluded that the spores of these smut fungi must have been introduced with the seeds of the respective host plants.

The second problem relates to the question whether the spores brought inside of the flowers may be infective or not. Mr. S. Nakagawa<sup>1)</sup> of our former Branch Station at Matsuto (near Kanazawa city, the Prov. of Kaga) carried out an Experiment on this point early in 1897. He introduced the matured spores of *U. Tritici* into the flowers of wheat in the same field by means of a forceps. The infected seeds were sown in the ordinary time of the autumn of the same year. In the following year the ears, as soon as they appeared, were found to be all smutted. Similar experiments made by Mr. K. Yamada gave the same result.<sup>2)</sup> Soon afterwards I obtained similar results in flower infection with *U. Tritici* and *U. nuda*. Hence I concluded that the spores of those smuts which mature at the flowering time of the host and may be scattered easily by the wind, will be retained in the innerside of the seed and give rise to the smut disease during the next flowering time of the host plant.<sup>3)</sup>

Moreover, the above conclusion was also proved afterwards by Brefeld<sup>4)</sup> and Hecke.<sup>5)</sup> The latter author has clearly shown microscopically the presence of smut germs in the form of mycoplasma in the tissue of the embryo of the seed which matured after artificial flower infection. Hence, it is now clear that at least *Ustilago Tritici*, *U. nuda* and *U. Hordei* may naturally infest the respective host plants by the flower infection.

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1). Bull. Agr. Expert. St. Nishigahara, Vol. XII, No. 4, 1895. (Japanese.)

2). Rep. Local Agr. Soc. Kioto, 1896. (Japanese.)

3). Farmers Bull. Agr. Ex. St. Nishigahara, No. 11, 1900. S. Hori, Diseases of Agr. Plants, 1901. (Japanese.)

4). Untersuch. a. d. Gesammt. d. Myk. XIII, 1903.

5). Zur Theorie d. Blüteninfection des Getreides durch Flugbrand. (Berichte d. deutsch. Bot. Gesell. XXIII. Heft 6, s. 248. Taf. VIII, 1905.)

In regard to wind infection, Brefeld<sup>1)</sup> was the first who proved it experimentally with Indian corn smut. Since the latter smut may occur on any part above ground of the host, the character is quite different from that of the other smuts of cereals. He sprayed the sporidia of the smut on the young inflorescence, leaves, growing point and air roots of the host and succeeded to produce the smut blisters on any intended part. The Indian corn smut (*Ustilago Maidis*) can therefore infest any part of the host by wind, the only example among the numerous smuts of cereals.

In regard to the fourth question, whether the spores of smut fungi attached to the seed coat of the host plants are infective or not, I have tried many experiments, some of which have not yet been finished. The smut fungi used for seed infection were *U. Tritici*, *U. nuda*, *U. Hordei*, *U. Keiliana*, *U. Crameri*, *U. Panici-miliacei*, *Tilletia laevis*, and *Urocystis acculta*.

All the seeds used in the experiments were disinfected by the hot water treatment<sup>2)</sup> before the spore infection was carried out. That this hot water treatment prevents thoroughly the smuts above enumerated has been experimentally proved here already. The disinfected seeds, after being a little moistened with distilled water, were thoroughly mixed with the smut spores until the surface became brownish, and were directly sown in the usual manner at the proper season.

In spite of numerous trials, the seed infections with the spores of *U. Tritici*, *U. nuda*, *U. Hordei* and *U. Keiliana* yielded always negative results, while on the contrary the experiments with the spores of the following smut fungi always yielded positive results. The details will be described below.

### I. Infection of Italian millet (*Sctaria italica* var. *germanica*) with *Ustilago Crameri*.

#### A. Experiment in 1896.<sup>3)</sup>

On account of the absence of smut on the Italian millet in the vicinity

1). Untersuch. a. d. Gesamt. d. Mykologie, XI, 1895.

2). The seeds after being soaked for 7 hours in cold water were kept some minutes in water of 50°C and then immersed for 5 minutes in water of 55°C.

3). Bull. Expert. Station, Nishigahara, Vol. XI, No. I. (In Japanese.)

of Tokio, seed (var. *Wase*) from a field, in the Prov. of Nagano about 100 miles north west from Tokio, where the smut had caused much injury in the previous year, were used for the experiment.

Before sowing the seed, the latter was tested by the following method to see whether smut spores were attached to the seed coat or not. Ten grains were thoroughly washed with distilled water which was then evaporated. Thirty-eight spores were thus observed under the microscope. This proved clearly that the smut spores became attached to the seed coat by careless thrashing in the presence of smutted ears.

On July 2 this seed was sown in a plot of 108 square feet and at the same time a variety of *Akita* raised on our Station field also was sown in a check plot. At the harvesting time, September 25, 144 ears of *Wase* were observed smutted, while no smut at all was on *Akita*.

#### B. Experiment in 1897.<sup>1)</sup>

The smutted ears collected in the plot of the infection experiment carried on the previous year and preserved in a paper pocket, were gently ground in a mortar to break up the spore masses and the latter were then mixed with moistened seeds of *Wase* and *Akita* millet. These seeds were sown July 10 and the plants harvested October 1. The result was as follows :

Variety.	Remarks.	Area of a plot.	No. of the healthy ears.	No. of the smutted ears.	Percentage of the smutted ears.
Wase 1	mixed with the smut spores	216 sq. ft.	247	1234	83.3
" 2	"	324 "	386	1851	82.7
Akita	"	"	116	459	87.4
Wase	check	"	1394	80	5.4
Akita	"	"	758	0	c

1). Bull. Expt. St. Nishigahara, Vol. XIII, No. I. (In Japanese.)

C. Experiment in 1898.<sup>1)</sup>

The experiment carried on the previous year was repeated with the seeds of *Wase* and *Akita* millet. The seeds were sown July 5 and the plants harvested September 21. The result was as follows :

Variety.	Remarks.	Area of a plot.	Sound ears.	Smutted ears.	Percentage of the smutted ears.
<i>Wase</i>	mixed with the smut spores	108	374	324	46.4
<i>Akita</i>	"	"	304	266	46.6
<i>Wase</i>	check	"	311	9	2.8
<i>Akita</i>	"	"	356	12	3.0

In this year the smut not only appeared to a small extent on the check plot of both *Wase* and *Akita* millet, but it was found also on some other varieties of millet in the experiment field (20 varieties were cultivated) on which the smut had not been observed before. But it was soon discovered that this unexpected result was due to negligence since the mats and implements which had been used for harvesting and thrashing the infected millet of the year before, had been used without previous disinfection.

For determining exactly the percentage of the smutted ears produced by the spore infection in the plot, the thinning process was not carried out. On this account, the growth of the millet plants was very irregular, most of which beared no seeds. Moreover, the smut being concealed entirely in the inside of the seed coat for a long time, it requires the greatest care and experience to recognize smutted ears especially when unripe. This difficulty was the cause of the smutted ears being thrashed together with sound ones.

*Conclusion* : By the results obtained during the last 4 years it was therefore decidedly proven that the smut of Italian millet is produced by

1). Bull. Expt. Station, Vol. XV, No. I, Nishigahara, 1899 (Japanese).

the spores adhering to the seed coat, where they have been carried by uncautious treatment in harvesting and thrashing or to some extent by the wind while the plants are standing in the field.

## II. Infection of wheat with *Tilletia laevis*.

### A. Experiment in 1898.<sup>1)</sup>

Bunt or Stinking smut of wheat caused by *Tilletia Tritici* or *T. laevis* is entirely absent in the vicinity of Tokio, but it may occur to a small extent in some localities of Japan. The smut for my infection experiments was obtained 2 years ago (Feb. 1896) from a grower in the Prov. of Shinano and was preserved in the herbarium in a paper pocket. The smutted grains were carefully ground in a mortar to break up the spore masses and the spores were then mixed with moistened seeds of wheat (d'Australie). These seeds were sown October 31 and the plants harvested June 9 in the following year. The result was as follows :

Remarks.	No. of seeds sown.	Area of a plot.	No. of smutted ears.
Seeds mixed with spores ...	3000	324 sq. ft.	430
Check ... ..	"	" "	0

Further the number of diseased plants was examined in order to show how many seeds are infected and how many ears were produced from the infected seeds. The result was as follows :

No. of seed sown mixed with the spores.	No. of actually infested seeds.	Percentage of infested seeds.	No. of ears produced from infected 164 grains.	
			Smutted.	Sound.
3000	164	5.46	430	50

1) Bull. Expt. St. Nishigahara 1901, No. XVIII (Japanese).

## B. Experiment in 1904.

The smutted grains for these experiments were obtained from the Breeding Farm in the Prov. of Shimosa belonging to the Imperial Court. The original seeds (*Ishima*) came from the Prov. of Idzumo in 1903, which had suffered great damages by the smut. Repeated experiments showed that the most spores of the smut had lost their germinating power. The wheat grains raised in our Station field were nevertheless mixed with these spores and sown Nov. 1. The wheat was harvested June 15, 1905 with the following result :

Remarks.	Area of a plot.	Number of smutted ear.
Seeds mixed with spores ... ..	324 sq. ft.	92
Check ... ..	" "	0

The comparatively small number of the smutted ears clearly shows that the smut spores for the most part had lost their infective power owing to an uncautious preservation of the sample. But nevertheless the result agrees as a whole with that of the previous experiments.

## C. Experiment in 1905.

The smutted grains produced in the plot of the previous infection experiment and preserved in a paper pocket, were carefully ground and mixed with moistened wheat grains (*Fultz*). These seeds were sown October 27, 1905 and the plants harvested June 8, 1906. The result was as follows :

Remarks.	Area of a plot.	Number of smutted ear.
Seeds mixed with spores ... ..	324 sq. ft.	827
Check ... ..	" "	0

From the results obtained in the last 3 years we may conclude the following :



1. Stinking smut of wheat is produced by the spores adhering to the seed coats. Uncautious thrashing is the only possible way by which the spores reach these spots.

2. Three years old spores still possess infective power.

3. Infected grain produces mostly smutted ears, but often healthy ears are also found among them.

### III. Infection of Wheat with *Urocystis occulta*, Rabenh.

#### A. Experiment in 1898.<sup>1)</sup>

The smut produced by the attack of *Urocystis occulta* being most abundant on rye is commonly known as rye smut or Roggenstengelbrand, but this smut also occurs occasionally on oats and barley in Europe and has been found according to Wolf on wheat in Australia. In Japan I first observed this smut on wheat in the vicinity of Ōita in Kiushu in 1895. Since then it has also been found in several other localities on wheat, but not yet on barley, oats or rye. The latter two kinds of cereals, however, are seldom cultivated in Japan. The most noticeable outbreak of this smut on wheat was observed in 1898 in a field in the Prov. of Kai where all plants of an area of about  $\frac{1}{4}$  of an acre were entirely destroyed before flowering time. But such great damage to wheat is thus far an exceptional case.

The smut spores for my infection experiments were obtained from the smutted wheat just mentioned, by slightly shaking the plants. The spores were then mixed with the moistened grains (d' Australie) which were sown October 30. The plants were harvested June 6 in the following year. The result was as follows :

Remarks.	Number of seeds sown.	Number of smutted plants.
Seeds mixed with the spores. ... ..	3000	1347
Check ... ..	"	0

1). Bull. Nishigahara Expt. St. No. XVIII, 1901 (Japanese).

Further it was noted how many plants were smutted, showing the number of the actually infested seeds. The result was as follows :

No. of seed sown.	No. of seeds produced the smutted plants.	No. of plants produced from the actually infested seeds.	
		Smutted.	Healthy.
3000	440	1347	1042

#### B. Experiment in 1899.

The smutted plants produced in the plot of the previous infection experiment and preserved in a paper pocket, served in the same way for the following experiment. The infected seeds were sown October 31 and the plants harvested June 30 in the following year with the following result :

Remarks.	Number of seeds sown.	Number of smutted plants.
Seeds mixed with the spores ... ..	3000	1534
Check ... ..	..	0

How many seeds sown produced smutted plants is seen from the following table :

No. of seeds sown.	No. of seeds produced the smutted plants.	No. of plants produced from the actually infested seeds.	
		Smutted.	Healthy.
3000	524	1534	1256

*Conclusion :* These two years experiments decidedly prove that the smut is produced by the spores of *Urocystis occulta* adhering to the seed coat whither they have been carried by careless thrashing. But it may be possible to some extent, that the matured spores, being easily scattered by winds, could also reach the innerside of the flowers and thus may be kept until thrashing time.

Infected grains produced both smutted and healthy plants nearly in the ratio of 3 : 2 without reducing the power of off-shooting.

IV. Infection of Millet (*Panicum Miliaceum*) with *Ustilago Panici-miliacci* (Pers.) Winter.

A. Experiment in 1899.<sup>1)</sup>

In August 1898, a farmer in the Prov. of Tokachi, Hokkaido sent to our Station some specimens of millet smut which year after year had caused great damage leading sometimes to the entire loss of a harvest, and asked for a proper method of prevention. Until then millet smut had never been reported, though millet is commonly cultivated throughout Japan. But according to recent researches, it becomes clear that millet smut is restricted to Hokkaido and to some localities of Mutsu, the northernmost province of Hondo (Main island) of Japan. The specimens received astonished us, and led us to a series of experiments in 1899.

The smutted panicles were carefully ground and then mixed with the millet seeds raised in our Station field. The seeds were sown July 10 and the plants harvested August 23. The result was :

Remarks.	Area of a plot.	No. of smutted plants.
Seeds mixed with spores ... ..	288 sq. ft.	567
Check ... ..	" "	0

The appearance of smutted panicles closely resemble that of Sorghum smut (*U. Reiliana*), but the difference is that the smutted panicles covering the shinning white membrane, are concealed for a longer time between the green leaves and that the infested plants remain of a greenish color, while the healthy plants become yellowish in ripening. When the main panicle was smutted, the secondary panicles, beginning to grow from the lower leaf-axis, were all found smutted too.

1). Bull. Nishigahara Expt. St. No. XVIII, p. 10, 1901 (Japanese).

## B. Experiment in 1900.

Smuted panicles from the previous infection experiment, served now for the next experiment. The seeds were sown July 6 and the plants harvested August 20. The result was :

Remarks.	Area of a plot.	No. of smuted panicles.
Seeds mixed with spores ... ..	360 sq. ft.	791
Check ... ..	" "	0

## C. Experiment in 1906.

The smut spores for the experiment were two years old and obtained from Hokkaido Experiment Station. Two grams of these spores were mixed with 45 grams of millet seeds which were then sown July 10. The plants yielded, on being harvested September 27, the following result :

Remarks.	Area of a plot.	No. of ears.	
		Smuted	Healthy
Seed mixed with spores ... ..	468 sq. ft.	3135	3160
Check ... ..	" "	0	not counted

*Conclusion :* By these three years experiments it becomes evident that the millet smut is produced by the spores of *Ustilago Panic-miliacei* adhering to the seed coat whither they have been carried by careless thrashing. This was clearly proved also by the following facts. The millet in central and southern Hondo is commonly harvested by cutting the ripened, healthy panicles only, so that there is no occasion for the smut spore adhering to the seed coat in thrashing. In Hokkaido, however, the entire millet plants are cut near the ground regardless of disease and then thrashed; thus the smut spores of the smuted panicles, can adhere to the seed coat. Hence the real cause of millet smut being restricted to Hokkaido is clear.

In 1902, Mr. Y. Takahashi<sup>1)</sup> of the Hokkaido Agricultural Experiment Station in Sapporo, carried out also such infection experiments with the millet seeds and smutted panicles also obtained from the Prov. of Tokachi. The result of his experiment was :

Remarks.	Area of a plot.	No. of smutted plants.
Tokachi millet seeds ... ..	360 sq. ft.	465
Same seeds mixed with spores ... ..	" "	Almost all the plants were smutted.

This result essentially agrees with mine.

In addition, a few words may be permitted as regards the infection experiments with millet smut by Brefeld.<sup>2)</sup> His method does not decide the present question whether the smut spores adhering to the seed coat are infective or not. He sprayed the germinated spores on very young millet seedlings and for securing the inoculation the latter were kept one week under a cover, and then transplanted to the field. By this method he obtained 60-70% of smutted plants.

#### SUMMARY.

Soil infection, although known in other cases, does not generally take place by the smuts of cereals ; such a case would constitute surely a very rare exception, at least in Japan.

The smuts of cereals may be classified as follows according to their respective mode of natural infection :

Ustilago Tritici.	Flower infection.
„ Hordei.	„
„ nuda.	„
„ Maidis.	Wind infection.
„ Panici-miliacei	Seed infection.
„ Crameri.	„
„ Reiliana.	„ ?
„ Sorghi.	„ ?

1). Bull. Hokkaido Agr. Expt. St. No. I, p. 112, 1902 (Japanese).

2). Untersuch. a. d. Gesamt. d. Myk. Heft XIII. p. 59, 1905.

Ustilago Avenae.	Seed infection.	?
„ laevis.	„	?
Urocystis occulta.	„	
Tilletia laevis	„	
„ Tritici.	„	? *

\* The interrogation mark signifies that the experiments with the particular smuts are not yet finished.

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Coccidæ of Japan, I.

**A Synoptical List of Coccidæ of Japan with Descriptions  
Of Thirteen New Species.**

BY

**S. I. KUWANA.**

INTRODUCTION.

In this paper are listed 97 species of Coccidæ in Japan, which were collected, during the past three years, by the writer and other members of the Division of Entomology, in the Imperial Agricultural Experiment Station, and were studied by the author. Thirteen of these species are new and are described under the following names :

- Icerya okadae.*
- Cerococcus muratae.*
- Kermes vastus.*
- Kermes miyasakii.*
- Eriococcus lagerstroemiac.*
- Dactylopius takae.*
- Ripersia japonica.*
- Ripersia oryzae.*
- Aclerida (?) bivakocensis.*
- Pulvinaria kuwacola.*
- Lecanium kunoensis.*
- Lecanium glandi.*
- Lecanium nishigaharac.*

## FAMILY COCCIDAE.

## Subfamily Orthezinae.

## GENUS ORTHEZIA BASC.

1. *Orthezia* Sp.

Hab. In Japan, on *Polygonum* (Tade).

## Subfamily Monophlebinae.

## GENUS MONOPHLEBUS BURM.

2. *Monophlebus maskelli* (ckll.).

*Monophlebus burmeisteri* Mask. (Not Westw.), N. Z. trans., XXIX,  
p. 327, (1892).

„ „ Kuw. (Not Westw.), Pr. Cal. Ac. Sci., (3), iii,  
p. 46, (1892).

„ *maskelli* Ckll., Science, N. S., XV, p. 718 (1902).

Hab. In Japan, on *Aegle sepiaria* (karatachi), wild grapes, cherry,  
mulberry, orange, *Zelkova acuminata* (keyaki), *Thea sasanqua*  
(sazanka) and pine.

3. *Monophlebus corpulentus* (Kuw.).

*Monophlebus corpulentus* kuw., Pr. Cal. Ac. Sci., (3), iii, p. 46, (1902).

Hab. In Japan, on *Quercus* Sp.

## GENUS ICERYA Sig

4. *Icerya okadae* N. Sp. (Pl XXVIII, Figs. 1-10).

*Adult female*.—Length about 5 mm. oval in shape; slightly narrower toward anterior end. On the margins of the body are rows of cottony fringes, and the dorsal aspect with three longitudinal rows of cottony projections; they are snow white with the yellow tips. Many long, silverly hairs on dorsal aspect. The egg sac is snow white.

Antennae are composed of eleven segments, about 1 mm. in length;



terminal segment the longest; second and third segments are next; the others subequal; each segment bears many long hairs. Legs subequal; tarsus not longer than one half the length of the tibia; claw long, slender, slightly curved, bears two spiny digitules at the base.

*Newly hatched larva*.—Length 1 mm., width 0.5 mm., oval in shape; antennae are composed of six segments; the sixth segment is longer than the rest, and club-shaped; all the segments except the first have a few hairs, while the sixth has several, of which four are very long. Legs long and slender; tibia a little longer than the tarsus. Posterior end of the body has six long hairs.

Hab. In Japan, on orange tree.

### Subfamily Margarodinae.

#### Tribe Xylococcini.

GENUS SASAKIA Kuw.

#### 5. *Sasakia quercus* Kuw.,

*Sasakia quercus* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 47 (1902).

„ *quercus* Ckll., The Ent., XXXV, p. 258, (1902).

*Kuwania* Ckll., in litt., (1902).

Hab. In Japan, on *quercus myrsinaefolia* (Shiragashi) and *quercus acuta* (katagi).

### Subfamily Coccinae.

#### Tribe Asterolecanium.

GENUS LECANIODIASPIS Targ.

#### 6. *Lecaniodiaspis quercus* (Ckll).

*Lecaniodiaspis quercus* Ckll, Psyche, vii, suppl., i, p. 19 (1896).

„ „ „ Bull. 4 T.S. Dep. Ag., U.S.A., p. 51 (1896)

„ „ Kuw. Pr. Cal. Ac. Sci., (3), iii, p. 48 (1902).

Hab. In Japan, on *Quercus acuta*, *Q. sessilifolia* (Tsukubanegashi) and *Pasania glabra* (Mate-gashi).

## GENUS ASTEROLECANIUM TARG.

7. *Asterolecanium variolosum* var. *japonicum* (Ckll).

*Asterolecanium variolosum* var. *japonicum* Ckll., Psyche, ix, p. 71 (1900).

Hab. In Japan, on *Quercus glandulifera* (kunugi).

## GENUS CEROCOCCUS COMST.

8. *Cerococcus muratae* N. Sp. (Pl. XXIX, Figs. 11-17).

♀ *Test.*:—Length 5 to 6 mm., width 4 to 5 mm., height about 3 mm. barnacle-shaped, with several white bands which are radiate from the cone; mounted with reddish brown exuvia. Subtransparent brownish red in color. Posterior end of the test bears a tube-like projection.

*Adult female*:—Length 4 to 5 mm; regular in outline and ball-shaped. The terminal segment of the body is the only one that is plainly distinguished from the others; it is strongly chitinized, and ends with two prominent lobes; each lobe has a long spiny hair at its extremity and bears several short ones on its inner margin. Mouth parts large, well formed. Antennae rudimentary, conical in shape, bear several short hairs. Legs wanting, spiracles prominent. Skin has many figure-8-shaped pores. Anal opening very large, with 8 long prominent hairs.

*Newly hatched larva*:—Length 532  $\mu$ , width 200  $\mu$ , elliptical in form, and distinctly segmented; the tip of the abdomen is furnished with two lobes, each terminating with a long hair. Anal opening is placed between these two lobes and is surrounded by several long hairs. Four longitudinal rows of figure-8-shaped pores on the dorsum. Mouth parts well formed; postal loop very long; mentum conical in shape. Antennae are composed of six segments; the third segment the longest, the other subequal. Legs well developed, tibia more than twice as long as tarsus; claw large and slightly curved. Posterior end of the body ends with two lobes, each of which bears a long hair.

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The name of this species is honor to Mr. Tōichi Murata of this station, who assisted me in my work in many ways.

Hab. In Japan, on *Viburnum odoratissimum* (sango-ju), and grape.

Type in the entomological collection of the Imperial Agricultural Experiment Station.

### Tribe Kermesini.

#### GENUS KERMES BOITARD.

##### 9. *Kermes nakagawae* (Kuw.).

*Kermes Nakagawae* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 49 (1902).

Hab. In Japan, on *Quercus glandulifera*.

##### 10. *Kermes nawae* (Kuw.).

*Kermes nawae* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 49 (1902).

Hab. In Japan, on *Quercus glandulifera*.

##### 11. *Kermes vastus* N. Sp. (Pl. XXIX, Figs. 18-21).

*Adult female*:—Diameter 8 to 10 mm., vary globose in form, with a very slightly longitudinal groove on the meson; shiny, chestnut brown in color, with black bands; when taken off the specimens from the host, leaves behind a little cottony white secretion. Antennae very short; composed of seven segments; the first and second segments subequal and the longest; fourth segment next to the longest; sixth and seventh segments subequal and the shortest. Legs small; femur slightly longer than tibia; tarsus shorter than tibia and tapering toward the posterior extremity; claw short and curved. Mouth parts large, well chitinized; mentum rather large, conical in shape; rostral loop very long.

Hab. In Japan, on *Quercus glandulifera*.

Type in the entomological collection of the Imperial Agricultural Experiment Station.

##### 12. *Kermes miyasakii* N. Sp. (Pl. XXIX, Figs. 22-28).

*Adult female*:—4 to 5 mm. in diameter; globose in form; shiny dark brown in color, with several transverse black bands; slightly covered with a waxy secretion. Exuvia is found on the dorsum. Antennae rudimentary,

about 95  $\mu$ . in length, and are composed of five segments; second segment the longest, almost as long as all the others taken together. Legs very rudimentary; femur not very much longer than tibia.

*Newly hatched larva*.—380  $\mu$ . in length; oval in form, with segmentation distinct. Antennae are composed of six segments, about 85  $\mu$ .; sixth segment the longest. Mouth parts large, well chitinized; rostral loop more than twice as long as the length of the body. Legs well formed; tarsus longer than tibia. Posterior end of the body is divided into two lobes, each of which bears a long spiny hair and many spines.

Hab. In Japan on *Quercus serrata*.

Type in the entomological collection of the Imperial Agricultural Experiment Station.

### Tribè Eriococcini.

#### GENUS ERIOCOCCUS TARG.

##### 13. *Eriococcus graminis* (Mask).

*Eriococcus graminis* Mask., Ent. mm., xxxiii, p. 243 (1897).

„ „ Kuw., Pr. Cal. Ac. Sci. (3), iii, p. 50 (1902).

Hab. In Japan, on bamboo.

##### 14. *Eriococcus onukii* (Kuw).

*Eriococcus onukii* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 51 (1902).

Hab. In Japan, on bamboo.

##### 15. *Eriococcus japonica* (Kuw.).

*Eriococcus japonica* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 5 (1902).

Hab. In Japan, on *Symplocos myrtacea* (Hainoki).

##### 16. *Eriococcus lagerstrecnieae* N. Sp. (Pl. XXX, Figs. 29-33).

*Adult female*.—Enclosed in oval sac about 6 mm. long and about 3 mm. wide; snow white in color.

Body, oval or broad elliptical in form, very plump, about 4 mm. in length, dark purple in color; dorsum has very spiny hairs. Antennae have

seven segments; second and third segments subequal, and the longest; each segment bears a few rather long spiny hairs. Legs subequal, comparatively small; tarsus a little longer than tibia. Posterior end of the body is terminated with two conical lobes, each of which bears a long hairs and many short spines. Anal ring with eight prominent hairs.

Hab. In Japan, on *Ficus carica* (Ichijiku), *Lagerstroemia indica* (Saruberi).

Type in the entomological collection of the Imperial Agricultural Experiment Station.

#### GENUS GOSSYPERIA SIG.

##### 17. *Gossyferia ulmi* Geoff.

*Coccus ulmi* Linn., Faun Suec., p. 265 (1761).

„ „ Geoff., Hist. Abr. Ins., i, p. 512 (1762).

„ *spurius* Mod., Act. Goth., i, p. 43 (1778).

„ *laniger* Gmel., Syst. Nat., Ed. xiii, p. 2221 (1789).

*Chermes ulmi* Latr., Hist. Nat. des Fourmis, p. 330 (1802).

*Nidularia lanigera* Targ., Catalogue, p. 34 (1869).

*Gossyperia ulmi* Sig., Ann. Soc. Ent. France, (3), v, p. 21 (1875).

„ *spuria* Ckll., Pr. Ac. N. Sci., Ph., p. 268 (1899).

„ *ulmi* Kuw., Pr. Cal. Ac. Sci., iii, p. 52 (1902).

Hab. In Japan, on elm.

#### Tribe Dactylopiini.

#### GENUS DACTYLOPIUS COSTA.

##### 18. *Dactylopius comstockii* (Kuw.).

*Dactylopius comstockii* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 52 (1902).

Hab. In Japan, on mulberry-tree and maple.

##### 19. *Dactylopius kraunhiaae* (Kuw.).

*Dactylopius kraunhiaae* Kuw., Pr. Cal. Ac. Sci., (3) iii, p. 55 (1902).

Hab. In Japan, on *Kraunhia floribunda* (Fuji).

20. *Dactylopius pini* (Kuw.)

*Dactylopius pini* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 54 (1902).

Hab. In Japan, on pine.

21. *Dactylopius takae* N. Sp. (Pl. XXX, Figs. 34-38).

*Adult female:* Length about 6 mm., width 3 mm.; elliptical in form; pale yellowish green in color and covered with a white cottony secretion.

Antennae are composed of eight segments; eighth segment the longest; second segment next to the longest; sixth segment the shortest; others subequal; formula; 8, 3, (1,2), 5, 4, 7, 6; terminal segment bears many long hairs. Mouth parts small, but well formed; muntum composed of two segments, conical in form. Legs large and subequal; coxa longer than wide; trocanter triangular in form, bears one long hair; femur the longest, and bears many spiny hairs on the anterior margin; tibia a little shorter than femur, and bears many strong spiny hairs on both sides; tarsus about one half the length of tibia, tapering posteriorly; claw strong, curved. The posterior end of the body is furnished with two well chitinized lobes, each lobe bears a long hairs and many spines. Anal ring with six prominent hairs.

Hab. In Japan, on bamboo.

Type in the entomological collection of the Imperial Agricultural Experiment Station.

22. *Dactylopius citri* (Risso).

*Dorthesia citri* Risso. Essai, Hist des Oranges (1893).

*Coccus citri* Bdv., Ent. Hort. p. 348 (1867).

*Dactylopius citri* Sign., Ann. oc. Ent. Fr., (5), v, p. 312 (1875).

*Lecanium phyllococcus* Ashm., Can. Ent., xi, p. 160, (1879).

*Dactylopius brevispinus* Targ., Annali di. Agr., p. 137 (1881).

„ destructor Comst., Rep. U. S. Dep. Ag. 1880, p. 342  
(1881).

Hab. In Japan, on orange.

23. *Dactylopius longispinus* Targ.

Coccus adonidum corpore roseo, etc., Geoff., Abr. Ins., i, p. 511 (1762).

Pseudococcus „ Westw., Mod. Class. Ins., i, Synop, p. 118 (1839).

Coccus „ Blanch, Hist. Nat. Ins., iii, p. 213 (1840).

Dactylopius longispinus Targ., Catalogue, p. 32 (1869).

„ adonidum Sign., Ann., Soc. Ent. Fr., (5), v, p. 306 (1875).

„ pteridis Sign. „ „ „ „ „ p. 321 (1875).

„ adonidum Licht., Bull. „ „ „ „ „ vi, p. lxiv (1876).

„ longifilis Comst., Rep. U. S. Dep. Agr., 1880, p. 341 (1881).

Hab. In Japan, on orange, pear, and plum.

## GENUS PHENACOCOCCUS CKLL.

24. *Phenacoccus pergandei* (Ckll.).

Phenacoccus pergandei Ckll., Psyche, vii, Suppl., i, p. 18 (1896).

„ „ Ckll., Bull. A. T.S. Dep. Agr. U. S., p. 55 (1896).

„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 56 (1902).

Hab. In Japan, on *Diospyros kaki*, (*Kaki*), mulberry-tree etc.

## GENUS SPHAEROCOCCUS MASK.

25. *Sphaerococcus parvus* (Mask).

Sphaerococcus parvus Mask., E. M. M., xxxiii, p. 244 (1897).

„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 56 (1902).

Hab. In Japan, on cherry.

## GENUS ANTONINA SIGN.

26. *Antonina crawi* (Ckll.).

Antonina crawi Ckll., Psyche, ix, p. 701 (1900).

„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 57 (1902).

Hab. In Japan, on bamboo.

## GENUS RIPERSIA SIGN.

27. *Ripersia japonica* N. Sp. (Pl. XXXI. Figs. 39-41).

♀ *Adult*:—Length 4 to 5 mm., width 2 to 2.5 mm.; long ovate in outline; dark purple in color; distinctly segmented, and thinly covered with a cottony secretion.

Boiled in KOH, the color turned into reddish purple; dorsum has many small round pits. Antennae are composed of seven segments, although sometimes only six; usually the seventh segment is the longest, bears many long hairs; there is great variation in the proportional length of the antennal segments, which appears in the following formulae:

- 6, 2, (1, 3), 4, 5.  
 6, 1, (2, 3), 4, 5.  
 7, (2, 4), 6, 5, 3, 1.  
 7, (3, 4), 6, 5, 2, 1.  
 7, 1, 2, 4, 6, (3, 5).  
 7, 1, 2, 3, 4, (1, 6).  
 6, 1, (2, 3), 5, 7, 4.  
 7, (2, 1), 3, 5, 6, 4.  
 7, 2, 1, 2, 6, (4, 5).  
 7, (1, 2), 4, 6, 5, 3.

Mouth parts well formed, but small; rostral loop short. Legs subequal; femur long and longer than tarsus; tarsal digitules long with fine hairs, while these on the claw are short and stout; claw large, slightly curved. Anal ring has six prominent hairs.

Hab. In Japan, lives under sheathing base of leaf of *Miscanthus* (Kaya).

Type in the entomological collection of the Imperial Agricultural Experiment Station.

28. *Ripersia Oryzae* N. Sp. (Pl. XXXI, Figs. 42-47).

♀ *Adult*:—Length about 2 mm., width about 1 mm.; oval in the outline; segmentation distinct; covered with white cottony secretion; pale yellow in color. Legs and antennae very short.



Antennae usually six segmented ; formulae :

2, 5, (1, 3, 4).

5, 2, 1, (3, 4).

6, (1, 2, 3), (4, 5).

6, 1, (2, 3, 4, 5).

Three pairs of legs are subequal, femur very long, almost as long as tibia and tarsus together ; tibia and tarsus usually about equal in length. Abdominal lobes very distinct and well chitinized ; each lobe bears many spiny hairs and a large hook-like appendage at the terminal end. Anal ring has six prominent hairs.

Hab. In Japan, found on the root of rice and other plants.

Type in the entomological collection of the Imp. Agr. Exp. Sta.

GENUS ACLERDA SIGN.

29. *Aclerda tokionis* (Ckll.).

Spheracocus (Pseudolecanium) tokionis Ckll., Psyche, vii, Supple., i,  
p. 19, (1896).

” ” ” Ckll, Bull, 4, T.S., Dep. Ag. p.  
49 (1896).

Pseudolecanium ”, Ckll., Pr. Ac. N. Sci. Ph., p.  
263 (1899).

” ” ” Kuw., Pr. Cal. Ac. Sci., (3), ii,  
p. 403 (1901).

” ” ” Kuw., Pr. Cal. Ac. Sci., (3), iii,  
p. 57, (1902).

Hab. In Japan, on bamboo.

30. *Aclerda(?) bivakaoensis* N. Sp. (Pl. XXXI, Figs. 45-54).

♀ *Adult*:—Length 4.5 to 7 mm., width 2 to 3.5 mm.; Ellipsoidal in form ; pinkish brown in color, when dried, chestnut brown. The sides of the body nearly parallel, with two shallow invaginations on each side of the body ; anterior end of the body round, slightly narrower than the posterior ; slightly covered, with a white cottony secretion. Boiled in KOH the body

becomes transparent, yellowish brown, with the margins golden brown. Mouth parts well chitinized, but rather small, and placed on the ventral aspect of the body, very near the middle. Antennae and legs are wanting. Many short captate spines on the dorsal aspect of the body. Posterior end of the body has no distinct cleft, but slightly inagenated.

Hab. In Japan, on *Rhizogmites communis* (Yoshi). The female lines under the sheathing base of the plant.

Type in the entomological collection of the Imperial Agricultural Experiment Station.

### Subfamily Lecaniinae.

#### GENUS PULVINARIA TARG.

##### 31. *Pulvinaria aurantii* (Ckll.)

*Pulvinaria aurantii* Ckll., Bull. 4, T.S. Dep. Ag. U. S., p. 48 (1896).

„ „ Ckll., Psyche, vii, Suppl., i, p. 19 (1896).

„ „ Ckll., Annali di Agr., p. 103 (1898).

„ „ Ckll., Pr. Ac. N. Sci. Ph., p. 272 (1899).

„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 58 (1992).

Hab. In Japan, on orange, tea plant, and others.

##### 32. *Pulvinaria psidii* (Mask.).

*Pulvinaria psidii* Mask., N. Z., Trans. xxv, p. 223 (1892).

„ „ How., Insect Life, vii, p. 426, (1895).

„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 58 (1902).

Hab. In Japan, on tea-plant, citrus, *Pittosporum tobira* (Tobera), *Eurya japonica* (sakaki) and others.

##### 33. *Pulvinaria kucvacola* N. Sp (Pl. XXXII, Figs. 55-58).

♀ *Adult*:—Length 6 to 8 mm., with 5 to 6 mm.; yellowish brown in color (dried specimen); suboval in form, with many transverse wrinkles on the dorsal aspect. Egg sac snow white, about 3 mm. long.

Antennae are composed of eight segments, third and fourth segments

subequal and the longest; many fine hairs on the terminal segment; formula: 3, 4, 2, 8, 1, 5, (6, 7). Legs stout and large; coxa is longer than wide, bears a few fine hairs; tibia almost three times as long as tarsus; claw is very strong slightly curved; digitules on tarsus have fine hairs, while that on the claw short and stout. Anal ring with six hairs. Triangular plates small.

Hab. In Japan, on mulberry.

Type in the entomological collection of the Imperial Agricultural Experiment Station.

34. *Pulvinaria Oyamae* (Kuw.).

*Pulvinaria Oyamae* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 60 (1902).

Hab. In Japan, on willow.

35. *Pulvinaria horii* (Kuw.).

*Pulvinaria horii* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 59 (1902).

Hab. In Japan, on *Acer trifidum* (To-kaede), *Aesculus turbinata* (To-chino-ki), and *Koelreuteria Paniculata* (Mokugenji).

36. *Pulvinaria hazae* (Kuw.).

*Pulvinaria hazae* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 59 (1902).

Hab. In Japan, on *Rhus succedanea* (Haze).

GENUS TAKAHASHIA CKLL.

37. *Takahashia japonica* (Ckll).

*Pulvinaria* (*Takahashia*) *japonica* Ckll., Psyche, vii, Suppl., i, p. 20 (1896).

„ „ „ Ckll., Bull., 4, T.S., Dep. Ag., U. S., p. 49 (1896).

*Takahashia japonica* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 61 (1902).

Hab. In Japan, on mulberry and others.

## GENUS ERICERUS GUIRIN.

38. *Ericerus pela* (Chav).

Coccus pe-la chav., Ann. Soc. Ent. Fr., (2), vi, p. 144, (1848).

„ „ Westw., Gard. Chron., pp. 484, 532 (1853).

Ericerus „ Guéi., Bull. Soc. Ent. Fr., (3), vi, p. lxxvii (1858).

„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 62 (1902).

„ „ Sasaki, Bull. Ag. College, Tokyo Imp. Univ., vol. vi, pp. 1-14 (1904).

Hab. In Japan, on *Ligustrum ibota* (Ibota-noki), *Viraxinus bungeana* (Toneriko).

## GENUS CEROPLASTES GRAY.

39. *Ceroplastes ceriferus* (And.).

Coccus Ceriferus Anderson, Mon. Cocciceriferi (1791).

Ceroplastes chilensis Gray, Spicilegia Zoologica, p. 7 (1830).

„ „ Sign., Ann. Soc., Ent. Fr., (5), ii, p. 40 (1872).

„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 62 (1902).

Hab. In Japan, on *Taonabo japonica* (Mokkoku), *Rhus succedanea* (Haze) etc.

40. *Ceroplastes floridensis* (Comst.)

Ceroplastes floridensis Comst., Rep. U. S. Dep. Ag., 1880, p. 331 (1881).

„ ruscii Ashm. (Non. Linn.), Can. Ent., xii, p. 252 (1880).

„ floridensis Kuw., Pr. Cal. Sci., (3), iii, p. 62 (1902).

Hab. In Japan, on tea plant, oleander, orange, *Thea sasanqua* (Sazan-kwa), *Gardenia florida* (Kuchinashi), etc.

## GENUS LECANIUM ILLIG.

41. *Lecanium hemisphaericus* (Targ.).

Lecanium hemisphaericum Targ., Studii sul. Cocc., pp. 26, 27, 30, 39, 63, (1867).

„ Coffeae Sign. (non Walk.), Ann. Soc. Ent. Fr., (5), iii, p. 435, (1873).

*Saissetia hemisphaerica* Ckll., The Ent. Student, ii, p. 32 (1901).

*Lecanium* (*Saissexia*)     ,     Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 63,  
(1902).

Hab. In Japan, on *Phajus grandiflorus* (kwakuran), *Gardenia florida*,  
coffee, *Asparagus plumosus*, etc.

42. *Lecanium kunoensis* N. Sp. (Pl. XXXII, Fig. 59-66).

♀ *Adult*.—Diameter, about 5 mm. (the largest); globose, with many  
small pits shiny chestnut in color.

Antennae are composed of seven segments, third segment the longest,  
almost equal to fourth fifth, sixth and seventh segment together. Legs sub-  
equal; femur and tibia subequal in length; tarsus less than one half of the  
length of tibia; claw short stout. Anal plate small.

Hab. In Japan, on *Rhamnus japonicus* (Kuro-ume-modoki), *Prunus  
mume* (ume), *Pirus sinensis* (Nashi) etc.

Type in the entomological collection of the Imp. Agr. Exp. Sta.

43. *Lecanium glandi* N. Sp. (Pl. XXXIII, Figs. 67-74).

♀ *Adult*.—Length about 15 mm. (the largest), width about 12 mm.,  
height about 10 mm.; subglobose in form; derm apparently thick; shiny  
chestnut brown in color, with many small shallow depressions; sloping  
posteriorly; and anal cleft very deep. Antennae are composed of eight  
segments; third segment the longest; others subequal. Legs rather short  
and weak; tarsus much shorter than tibia, claw stout and slightly curved  
anal plates normal.

Hab. In Japan, on apple, pear and other trees.

Type in the entomological collection of the Imperial Agricultural  
Experiment Station.

44. *Lecanium takachihoi* (Kuw.).

*Lecanium* (*Eulecanium*) *takachihoi* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 63  
(1902).

Hab. In Japan, on chestnut.

45. *Lecanium oleae* (Bern.).

Chermer oleae Bern., Mem. d'Hist. Nat. Acad., Marseille, p. 108 (1782).

Coccus oleae Oliv., Ency. Meth., vi, p. 95 (1791).

Lecanium oleae Walk., Cat. Br. Mus., Hom., p. 1070 (1852).

Saissetia oleae Ckll., The Ent. Student, ii, p. 31 (1901).

Lecanium (Saissetia) oleae Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 64 (1902).

Hab. In Japan, on *citrus*.

46. *Lecanium hesperium* (L.).

Coccus hesperidum Linn., Syst. Nat., Ed. x, i, p. 455 (1758).

Chermes ,, Geoff., Abr. Ins., i, p. 505 (1762).

Calypticus ,, Costa, Faun. Reg. Nap., Cocc., p. 8 (1835).

Calymmatus ,, Costa, Nuov. Osserve., p. 22 (1835).

Lecanium ,, Burm., Handb. Ent., ii, p. 69 (1835).

,, ,, Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 64, (1902).

Hab. In Japan, on *Abutilon* sp., *Nerium odorum* (Kyochikuto), *Jasminum* sp., *Cycas revoluta* (Sotetsu), *Eriobotrya japonica* (Biwa), *Cercis chinensis* (Hana-zuo), *Aegle sepiaria*.

47. *Lecanium nishigaharae* N. Sp. (Pl. XXXIII, Figs. 75-81).

♀ *Adult*.—Length 7 mm., width 6 mm., height 3 mm.; nearly hemispherical in form, with many transverse wrinkles and one or more longitudinal ridges on dorsum. Antennae are composed of eight segments; third segment the longest; formula; 3, 4, 2, 1, 8, 5, 6, 7. Legs subequal, well developed; tibia very much longer than tarsus. Anal plates usual.

*First larval stage*.—Length 855  $\mu$ , width 475  $\mu$ ; oval in form. Antennae have seven segments; third segment the longest; formula: 3, 7, 2, 1, 4, 5, 6.

Hab. In Japan, on mulberry tree.

This species is very closely allied to *Lecanium mori* sign., but the following characteristics distinguish these two species:

Lecanium mori sign.	Lecanium nishigaharae.
1. Antennae are composed of 7 segments.	1. Antennae are composed of 8 segments.
2. Tibia and tarsus are sub-equal.	2. Tibia is very much longer than tarsus.
3. Larval antennae are composed of 6 segments.	3. Larval antennae are composed of 7 segments.

Hab. In Japan, on mulberry.

Type in the entomological collection of the Imperial Agricultural Experiment Station.

48. *Lecanium frontale* (Green).

*Lecanium frontale* Green, Coccidae of Cylon, vol. iii, p. 192 (1904).

Hab. In Japan, on Palm.

49. *Lecanium tessellatum* (Sign).

*Lecanium tessellatum* sign., Ann. Soc. Ent. Fr., (5), iii, p. 401 (1873).

Coccus ,, Kirkaldy, Faun. Haw., iii, pl. 2, p. 106 (1902).

Eucalymnatus ,, Ckll., Ann. Mag. N.H., (7), ix, p. 453.

Hab. In Japan, on Palm.

### Subfamily Diaspinae.

#### GENUS ASPIDIOTUS BOUCHE.

50. *Aspidiotus inucitata* (Green).

*Aspidiotus inucitatus* Green, Coccidae of Ceylon, Part I, p. 65 (1902).

,, ,, Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 65, (1902).

Hab. In Japan, on bamboo.

51. *Aspidiotus secretus* (Ckll.).

*Aspidiotus secretus* Ckll., Psyche, vii, Suppl., i, p. 20 (1896).

,, ,, Ckll., Bull. 4., T. S., Dep. Agr. U. S., p. 51, (1896).

,, (Odonaspis) ,, Ckll., Bull. 6, T. S., Dep. Agr. U. S., p. 14, 20, 31, (1897).

*Spatheaspis secretus* Leon., Riv. Pat. Veg., vi, p. 115 (1897).

Hab. In Japan, on bamboo.

52. *Aspidiotus secreta*, var *lobulatus* (Mask.).

*Aspidiotus secretus*, var *lobulatus* Mask., Ent. Mon. Mag., xxxiii, p. 24, (1897).

” ” ” ” Mask., New Zealand Tran. xxx, p. 224 (1898).

*Spatheaspis* ” ” ” Leon., Gen. e Spec. Diaspiti, Asp., p. 221.

Hab. In Japan, on bamboo.

53. *Aspidiotus trilobiformis* (Green).

*Aspidiotus trilobiformis* Green, In. Mus. Notes vol. iv, p. 4 (1896).

” ” Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 66 (1902).

Hab. In Japan, on ?

54. *Aspidiotus duplex* (Ckll.)

*Aspidiotus duplex* Ckll., Psyche, vii, Suppl., i, p. 20 (1896).

” ” ” Bull. 4, T. S., U. S., Dep. Agr., p. 52 (1896).

” ” Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 66 (1902).

Hab. In Japan, on *Rhus succidanea*, *Eurya ochracea*, *Thea japonica*, *Aegle sepiaria*.

55. *Aspidiotus paeoniae* (Ckll.).

*Aspidiotus duplex*, var. *Paeoniae* Ckll., Can. Ent. xxxi, p. 105 (1899).

” ” ” ” Kuw., Pr. Cal. Ac. Sci., (3) iii, p. 66, (1902).

Hab. In Japan, on *Eurya ochracea*, *Thea chinensis*, *Rhododendron indicum* var. *Kaempferi* (Tsutsuji), *R. indicum* var. *Macranthum* (satsuki), *Ilex latifolia* (Taraya), *Clethra barbinervis* (Ryobu), *Thea japonica*, *Paeonia montan* (Botan), etc.



56. *Aspidiotus perniciosus* (Comst.).

- Aspidiotus perniciosus* Comst., Rep. U. S., Dep. Agr. 1880, p. 304 (1881).  
 „ „ var. *albopunctatus* Ckll., Psyche, vii, Suppl., i. p. 20 (1856).  
 „ „ var. *andromelas* Ckll., Bull. 6, T. S., Dep. Ag. U.S. p. 224 (1900).  
 „ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 67 (1902).  
 „ „ Kuw., San Jose Scale in Japan (1901, 1904).  
 Hab. In Japan, on pear, apple, peach, Japanese quince, currant, willow, *Paeonia moutan*, *citrus* etc.

57. *Aspidiotus rapax* (Comst.).

- Aspidiotus camelliae* Sign. (Non Bdv.), Ann. Soc. Ent. Fr., (4), ix, p. 117 (1869).  
 „ *convexus* Comst., Rep. U. S., Dep. Ag., 1880, p. 285 (1881).  
 „ *rapax* Comst., Rep. U. S., Dep. Ag., 1880, p. 307 (1881).  
 Hab. In Japan, on fruit tree from America.

58. *Aspidiotus ulmi* (John.).

- Aspidiotus ulmi* John., Bull. Ill., State Lab. N. Hist., iv, p. 388 (1896).  
 „ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 68 (1902).  
 Hab. In Japan, on elm.

59. *Aspidiotus cyanophylli* (Sign.).

- Aspidiotus cyanophylli* Sign., Ann. Soc., Ent. Fr., (4), ix, p. 119 (1869).  
 Hab. In Japan, on palm in green house.

60. *Aspidiotus lataniae* (Sign.).

- Aspidiotus lataniae* Sign., Ann. Soc. Ent. Fr., (4), ix, p. 124 (1869).  
 „ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 68 (1902).  
 Hab. In Japan, on tea plant.

61. *Aspidiotus cryptomeriae* (Kuw.).

*Aspidiotus cryptomeriae* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 69, (1902).  
Hab. In Japan, on *Cryptomeria japonica* (Sugi).

62. *Aspidiotus jordani* (Kuw.).

*Aspidiotus jordani* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 69 (1902).  
Hab. In Japan, on oak.

63. *Aspidiotus aurantii* (Mask.).

*Aspidiotus aurantii* Mask., N. Z. Trans., xi, p. 199 (1878).  
*Chrysomphalus* ,, Ckll., Check List. Suppl., p. 396 (1899).  
*Aspidiotus* (*chrysomphalus*) ,, Kuw., Pr. Cal. Ac. Sci., (3), iii, P. 70,  
(1902).  
Hab. In Japan, on *Podocarpus chinensis*, *Acacia*, orange and tea plant.

62. *Aspidiotus ficus* (Ashm.).

*Coccus aonidum* Linn., Syst. Nat., El. x, i, p. 455 (1758).  
*Chrysomphalus ficus* Ashm., Am. Ent., iii, p. 267 (1880).  
*Aspidiotus ficus* Comst., Rep. U. S., Dep. Ag., 1880, p. 296 (1881).  
,, (*Chrysomphalus*) *ficus* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 71 (1902).  
Hab. In Japan, on *Asparagus plumosus*, *Machilus Thunbergii* (Inugusu, Tabu-no-ki), mango, *Aspidistra lurida* (Baran), *Ligustrum japonicum* (Nezumimochi).

65. *Aspidiotus kelloggi* (Kuw.).

*Aspidiotus kelloggi* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 71 (1902).  
Hab. In Japan, on ?

66. *Aspidiotus bambusarum* (Ckll.).

*Aspidiotus* (*Odonaspis*) *bambusarum* Ckll., Psyche, viii, p. 191 (1898).  
Hab. In Japan, on bamboo.

## GENUS DIASPIS COSTA.

67. *Diaspis pentagona* (Targ.).

*Diaspis pentagona* Targ., Revista di Bacchicoltura, No. 11 (1885).

„ *amygdali* Tryon, Rep. on Fungous Pesla, p. 89 (1889).

„ *lanatus* Morg. and Ckll., Journ. Inst. Jam., i, p. 137 (1892)

? *Chionaspis prunicola* Mask., N. Z. Trans., xxvii, p. 49 (1894).

*Diaspis patelliformis* Sasaki, Bull. Ag. Coll., Tokyo, p. 107 (1894).

„ *pentagona* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 72 (1902).

Hab. In Japan, on cherry, plum, prune, peach, walnut, grape, mulberry, persimmon, geranium, etc.

68. *Diaspis Crawi* (Ckll.).

*Diaspis Crawi* Ckll., Psyche, viii, p. 190 (1898).

„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 73 (1902).

Hab. In Japan, on *gumi*.

69. *Diaspis rosae* (Bouchè).

*Aspidiotus rosae* Bouchè, Naturg. Ins., p. 14 (1834).

*Diaspis rosae* Sign., Ann. Soc. Ent. Fr., (4), ix, p. 441 (1869).

*Aulacaspis rosae* Ckll., Bull. Bot. Dep. Jam., p. 259 (1896).

„ „ Kuw., Pr. Cal. Ac., Sci., (3), iii, p. 73 (1902).

Hab. In Japan, on rose, *Rubus morifolius* (Kumaichigo).

70. *Diaspis rosae* var. *spinosa* (Mask.).

*Aulacaspis rosae* var. *spinosa* Mask., Ent. Mon. Mag., xxxiii, p. 241, (1897).

Hab. In Japan, on smilax.

## GENUS LEUCASPIS TARG.

11. *Leucaspis japonica* (Ckll.).

*Leucaspis japonica* Ckll., Psyche, viii, p. 53 (1897).

*Leucaspis japonica* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 741 (1902).  
Hab. In Japan, on apple, pear, orange, persimmon, etc.

72. *Leucaspis bambusae* (Kuw.).

*Leucaspis bambusae* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 74 (1902).  
Hab. In Japan, on bamboo.

GENUS CHIONASPIS SIGN.

73. *Chionaspis aspidistrae* (Sign).

*Chionaspis aspidistrae* Sign., Ann. Soc. Ent. Fr., (4), ix, p. 443 (1869).  
*Hemichionaspis* ,, Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 75 (1902).  
Hab. In Japan, on *Aspidistra lurida*, orchids, orange etc.

74. *Chionaspis euonymi* (Comst.).

*Chionaspis euonymi* Comst., Rep. U. S. Dep. Agr., 1880, p. 313 (1881).  
,, ,, Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 75 (1902).  
Hab. In Japan, on *Euonymus japonico* (Masaki).

75. *Chionaspis hikosani* (Kuw.).

*Chionaspis hikosani* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 76 (1902).  
Hab. In Japan, on bamboo.

76. *Chionaspis bambusae* (Ckll.).

*Chionaspis bambusae* Ckll., Psyche, vii, Supple., i, p. 21 (1896).  
,, ,, Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 76 (1902).  
Hab. In Japan, on bamboo.

77. *Chionaspis platani* (Cooley).

*Chionaspis platani* Cooley, Spec. Bull. Mass. Exp. Sta., p. 36 (1899).  
,, ,, Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 77 (1902).  
Hab. In Japan, on *Rhus sp.*

78. *Chionaspis wistariae* (Cooley).

*Chionaspis wistariae* Cooley, Can. Ent., xxix, p. 280 (1897).

*Chionaspis wistariae* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 77 (1902).  
Hab. In Japan, on wistaria (Fuji).

79. *Chionaspis colemani* (Kuw.).

*Chionaspis colemani* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 77 (1902).  
Hab. In Japan, on bamboo.

80. *Chionaspis citri* (Comst.).

*Chionaspis euonymi* Comst., Rep. U. S. Dep. Ag., 1880, p. 313 (1881).  
,, *citri* Comst., 2nd Rep. Ent. Corn. Univ., p. 100 (1883).  
Hab. In Japan, on *citrus*.

GENUS PARLATORIA TARG.

81. *Parlatoria proteus* (Curt.).

*Aspidiotus proteus* Curt., Gard. Chron., p. 676 (1843).  
*Daiaspis parlatoris* Targ., Studii Sul. Cocc., p. 14 (1867).  
(?) *Parlatoria orbicularis* Targ., Catalogue, p. 42 (1869).  
*Parlatoria proteus* Sign., Ann. Soc. Ent. Fr., (4), ix, p. 450 (1869).  
(?) *Aspidiotus targionii* Del. guer., 11, Naturalista Siciliano, No. 8 (1894).  
*Parlatoria proteus* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 79 (1902).  
Hab. In Japan, on *Angracum falcatum* (Furan), *Viburum odoratisimum* (sango-ju), *Thea sasanqua* (sazankwa), pear, apple, etc.

82. *Parlatoria pergandii* (Comst.).

*Parlatoria pergandii* Comst., Rep. U. S. Dep. Ag., 1880, p. 327 (1881).  
,, ,, Craw, Rep. Cal. Sta. Bd. Hort., 1897-98, p. 98.  
,, ,, Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 78 (1902).  
Hab. In Japan, on orange, pear, etc.

83. *Parlatoria theae* Ckll.

*Parlatoria theae* Ckll., Psyche, vii, Suppl., i, p. 21 (1896).  
,, ,, Ckll., Bull. 4, T.s., Dep. Ag. U. S. A., p. 55 (1856).

*Parlatoria pergandii* var. *theae* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 78 (1902).

Hab. In Japan, on *Acer crataegifolium* (Uri-kaede), *A. pictum*, (Itaya-kaede), *Diospyros Kaki* (Kaki), rose, *Cornus macrophylla* (Mizuki), *Osmanthus fragrans* (Mokusei) etc.

84. *Parlatoria ziziphus* (Lucas).

*Coccus ziziphus* Lucas., Bull., Soc. Ent. Fr., (3), i, xxviii (1853).

*Chermes aurantii* Bdv., Ent. Hort., p. 338 (1867).

*Parlatoria lucasii* Targ., Catalogue, p. 52 (1869).

„ *ziziphus* Sig., Ann. Soc., Ent. Fr., (4), ix, p. 451 (1869).

„ *lucasii* Targ., Annali di Agr., p. 398 (1884).

Hab. In Japan on orange. .

GENUS FIORINIA TARG.

85. *Fiorinia fioriniae* (Targ.).

*Diaspis fioriniae* Targ., Studii Sul. Cocc., p. 14 (1867).

*Chermes arecae* Bdv., Insectologie Agricole, p. 262 (1868).

*Fiorinia pellucida* Targ., Catalogue, p. 42 (1869).

„ *camelliae* Comst., Rep. U. S. Dep. Ag., 1880, p. 329 (1881).

*Uhleria fioriniae* Comst., 2nd. Rep. Dep. Ent. Corn. Univ., p. 111 (1881).

„ *camelliae* Comst., „ „ „ „ „ „ „ „

*Fiorinia fioriniae* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 79 (1902).

Hab. In Japan, on fern, *Thec japonica* etc.

86. *Fiorinia fioriniae*, var. *japonica* (Kuw.).

*Fiorinia fioriniae* var. *japonica* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 79 (1902).

Hab. In Japan, on *Podocarpus chinensis* (Maki), Pine.

GENUS MYTILASPIS SIGN.

87. *Mytilaspis pomorum* (Bauche).

*Coccus ulmi* Linn., Syst. Nat., Ed., 8, i, p. 455 (1758).

*Chermes arborum*, *linearis* Geoff., Abr. Ins., i, p. 509 (1762).

*Coccus linearis* Mod., Act. Goth., i, p. 22 (1778).

„ *conchiformis* Gmel., Syst. Nat., Ed. xiii, p. 222 (1789).

*Diaspis linearis* Costa, Fann. Reg. Nap., Cocc., p. 21 (1835).

*Aspidiotus conchiformis* Curt., Gord. Chron., p. 375 (1843).

*Mytilaspis falciformii* Baer., D'Alton, zeit. für Zool., p. 168 (1849).

*Lepidosaphes conchiformis* Shimer, Tr. A.M. Ent. Soci., i, p. 373 (1868).

*Aspidiotus pomarum* Bouché, Stett. Ent. Zeit., xii, p. 110 (1851).

*Mytilaspis pomarum* Sign., Ann. Soc. Ent. Fr., (4), x, p. 98 (1870).

„ „ Kuw., Pr. Cal. Ac. Sci., (3), ili, p. 80 (1902).

Hab. In Japan, on *Mespilus cuneata* (Sanzashi), *Ilex crenata* (Inutsuge), currant, apple.

88. *Mytilaspis pomorum* var. *japonica* (Kuw.).

*Mytilaspis pomorum* var. *japonica* Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 80 (1902).

Hab. In Japan, on *Abies firma* (Momi).

89. *Mytilaspis gloverii* (Pack).

*Coccus gloverii* Pack., Guide to Study of Insects., Ed. i. p. 527 (1869).

*Aspidiotus gloverii* Pack., 7th Rep. Mass. Bd. Ag., 1869, p. 259 (1870).

*Mytilaspis gloverii* Comst., Rep. U. S. Dep. Ag., 1876, p. 41 (1877).

„ „ Kuw., Pr. Cal. Ac. Sci., (3), iii, p. 81 (1902).

Hab. In Japan, on orange.

91. *Mytilaspis pallida* (Green).

*Mytilaspis pallida* Green, Ind. Mus. Notes, iv, p. 5 (1896).

„ *gloverii* var. *pallida* Green; Cocc. Ceylon, pt. i, p. 85 (1896).

*Lepidosaphes pallida* Kirkaldy, Fauna Haw., iii, pt. 2, p. iii (1902).

Hab. In Japan on *foliolarpus* sp., citrus.

92. *Mytilaspis beckii* (Newm).

*Coccus beckii* Newm., The Ent., iv, p. 217, (1869).

*Aspidiotus citriicola* Pack., Guide to study of Insects, p. 527 (1869).

*Coccus anguinus* Bdv., *Insectologie Agricole*, iv (1870).

*Mytilaspis fulva*. Targ., *Bull. Soc. Ent. Ital.*, p. 131 (1872).

„ *flavescens* Targ., *Annali. R. Minist. Agr.*, p. 84 (1876).

„ *citricola* comst., *Rep. U.S. Dep. Ag.*, 1880, p. 321 (1881).

„ „ Kuw., *Pr. Cal. Ac. Sci.*, (3), iii, P. 81 (1902).

Hab. In Japan, on *citrus*.

93. *Mytilaspis newsteadi* (Sulc).

*Mytilaspis newsteadi* Sulc, *Sitzb. K. Bhom. Ges. Wiss.*, No. xlix, pp. 8, 19 (1895).

„ „ Kuw., *Pr. Cal. Ac. Sci.*, (3), iii, p. 82 (1902).

Hav. In Japan, on *Theae japonica*.

94. *Mytilaspis newsteadi* var. *tokionis* (Kuw).

*Mytilaspis newsteadi* var. *tokionis* Kuw., *Pr. Cal. Ac. Sci.*, (3), iii, p. 81 (1902).

Hab. In Japan, on *Cadiacum*.

95. *Mytilaspis crawi* (Ckll).

*Mytilaspis crawi* Ckll., *Psyche*, vii, suppl., i, p. 21 (1896).

*Mytilaspis crawi* Ckll., *Bull. 4. T.S., Dep. Ag. S.*, P. 44 (1896).

„ „ Kuw., *Pr. Cal. Ac. Sci.*, (3), iii, P. 82 (1902).

Hab. On Japan, on oak.

GENUS POLIASPIS Sign.

96. *Poliaspis pini* (Mask.)

*Poliaspis pini* Mask., *E. M. M.*, xxxiii, p. 242 (1897).

„ „ „ „, *N.Z. Trans.*, XXX, p. 231 (1898).

„ „ Kuw., *Pr. Cal. Ac. Sci.*, (3), iii, p. 82 (1902).

Hab. In Japan, on pine.

GENUS ISCHNASPIS (Doug).

97. *Ischnaspis longirostris* (Sign).

*Mytilaspis longirostris* Sign., *Bull. Soc. E. Fr.*, (6), ii, p. 25 (1882).

*Ischnaspis filiformis* Dougl., *E. M. M.*, vol. xxiv, 1897.

Hab. In Japan, on palm.



## LIST OF COCCIDAE RECORDED IN JAPAN, NOT INCLUDED IN THE

## FOREGOING LIST.

1. *Dactylopius syringae* Mask.
  2. „ *edgeworthiae* Ckll.
  3. „ *virgatus* Ckll.
  4. *Sphaerococcus populi* Mask.
  5. *Asterolecanium delicata* Green.
  6. *Lecanium notatum* Mask.
  7. „ *cerasorum* Ckll.
  8. *Ceronema japonica* Mask.
  9. *Aspidiotus cryptoxanthus* Ckll.
  10. „ *setiger* Mask.
  11. „ *aurantii* var. *citrinus* Coqu.
  12. *Diaspis auranticolar* Ckll.
  13. *Aonidia elaeagnus* Mask.
  14. *Chionaspis chinensis* Ckll.
  15. „ *engeniae* Mask.
  16. „ *aucubae* Codey.
  17. „ *difficilis* Ckll.
  18. „ *graminis* Green.
  19. „ *vitis* Green.
  20. „ *latissima* Ckll.
  21. „ *citri* Comst.
  22. *Fiorinia signata* Mask.
  23. „ *tenuis* Mask.
  24. *Mytilaspis machili* Mask.
  25. „ *crawi* var. *canaliculata* Mask.
  26. „ *pallida* var. *maskelii* Ckll.
  27. *Parlatoria theae* var. *viridis* Ckll.
  28. „ „ „ *euonymi* Ckll.
  29. „ *proteus virescens* Mask.
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## EXPLANATION OF PLATES.

## PLATE XXVIII.

*Icerya Okadae*.

Fig.	1.	Female with host (Lateral aspect).	× 2
„	2.	„ (Dorsal aspect).	× 6
„	3.	Antennae of female.	Z. 3 × AA.
„	4.	Leg of female.	Z. 2 × AA.
„	5.	Spiny hairs and round pits of dorsal aspect of female.	Z. 3 × AA.
„	6.	„	Z. 1 × E.
„	7.	Pit of dorsal aspect of female.	Z. 3 × E.
„	8.	First larval stage.	Z. 3 × AA.
„	9.	Antennae of first larval stage.	Z. 3 × C.
„	10.	Leg of the same.	

## PLATE XXIX.

*Cerococcus muratae*.

Fig.	11.	Scales on host.	Natural size.
„	12.	Scale	× 5
„	13.	Posterior end of the body of female.	Z. 1 × E.
„	14.	Antennae of female.	Z. 3 × E.
„	15.	Larva.	Z. 3 × AA.
„	16.	Antennae of larva.	Z. 1 × E.
„	17.	Leg of larva.	Z. 1 × E.

*Karmes vastus*.

Fig.	18.	Adult female.	Natural size.
„	19.	„	× 5
„	20.	Antennae of the same.	Z. 1 × E.
„	21.	Leg of the same.	Z. 1 × E.

**Kermes miyasakii.**

Fig. 22.	Adult females on host,	Natural size.
„ 23.	Female.	
„ 24.	Antennae of the same.	Z. 1 × E.
„ 25.	Leg of the same.	Z. 1 × E.
„ 26.	Antennae of larva.	Z. 1 × E.
„ 27.	Leg of the same.	Z. 1 × E.
„ 28.	Abdominal end of the same.	Z. 3 × E.

## PLATE. XXX.

**Eriococcus lagerstroemiae.**

Fig. 29.	Females on host,	Natural size.
„ 30.	Antennae of female.	Z. 1 × C.
„ 31.	Leg of the same.	Z. 1 × C.
„ 32.	Abdominal end of the same.	Z. 1 × C.
„ 33.	Dorsal spines of the same.	Z. 3 × C.

**Dactylopius takae.**

Fig. 34.	Females with host,	Natural size.
„ 35.	Female.	Enlarged.
„ 36.	Antennae of the same,	Z. 1 × C.
„ 37.	Leg of the same.	Z. 3 × AA.
„ 37 a.	Tarsal segment.	Z. 3 × C.
„ 38.	Abdominal end of female.	Z. 3 × C.

## PLATE. XXXI.

**Ripersia Japonica.**

Fig. 39.	Antennae of adult female.	.
„ 40.	Leg of the same.	
„ 41.	Last abdominal segment of the same.	

**Ripersia oryzae.**

Fig. 42.	Females with rice stab.	Natural size.
„ 43.	Female with youngs.	Enlarged.
„ 44.	Female	Z. 1 × AA.
„ 45.	Abdominal end of the same.	Z. 1 × E.
„ 46.	Antennae of the same.	Z. 1 × E.
„ 47.	Leg of the same.	Z. 1 × E.

**Aclerda biwakoensis.**

Fig. 48.	Females with host.	Natural size.
„ 49.	Female	× 15
„ 50.	Abdominal end of the same.	Enlarged.
„ 51.	„	„
„ 52.	Spines of lateral aspect of the abdominal end.	Z. 4 × D.
„ 53.	Spines of lateral aspect of the body.	Z. 4 × D.
„ 54.	Marking of dorsal aspect of the female.	Z. 4 × D.

## PLATE. XXXII.

**Pulvinaria kuwacola.**

Fig. 55.	Females on host.	Natural size.
„ 56.	Spines at the lateral incision.	Z. 1 × C.
„ 57.	Antennae of female.	Z. 1 × C.
„ 58.	Leg of the same.	Z. 1 × C.

**Lecanium Kunoensis.**

Fig. 59.	Females on host.	about × 2
„ 60.	„	Natural size.
„ 61.	Antennae of female.	Z. 1 × E.
„ 62.	Leg of the same.	Z. 1 × E.
„ 63.	Lateral spines of female.	Z. 1 × E.
„ 64.	Triangular plate of the same.	Z. 1 × E.

- Fig. 65. Marking of dorsal aspect of female. Z. 1 × E.  
 „ 66. Marking of ventral aspect of female. Z. 1 × E.

## PLATE. XXXIII.

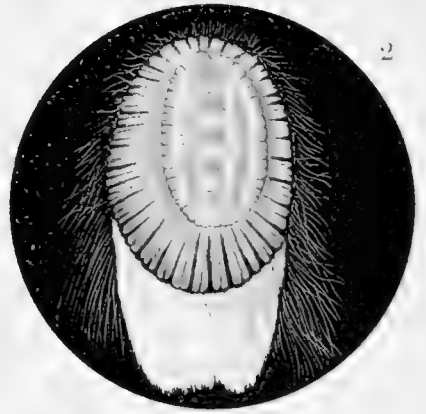
**Lecanium glandi.**

- Fig. 67. Adult female. Natural size.  
 „ 68. The same. × 5  
 „ 69. Antennae of the same. Z. 2 × C.  
 „ 70. Leg of the same. Z. 4 × AA.  
 „ 70. a Tarsus of the same. Z. 4 × E.  
 „ 71. Spines of marginal incision. Z. 4 × E.  
 „ 72. Spines of abdominal end of the body of female. Z. 3 × AA.  
 „ 73. Marking of skin of female. Z. 1 × E.  
 „ 74. Triangular plates of female. Enlarged.

**Lecanium nishigaharae.**

- Fig. 75. Females on host. Natural size.  
 „ 76. Female. × 5  
 „ 77. Antennae of the same. Z. 1 × C.  
 „ 78. Leg of the same. Z. 1 × C.  
 „ 79. Spines of marginal incision. Z. 1 × C.  
 „ 80. Triangular plates of female. Z. 1 × C.  
 „ 81. Marking of skin of female. Z. 2 × C.
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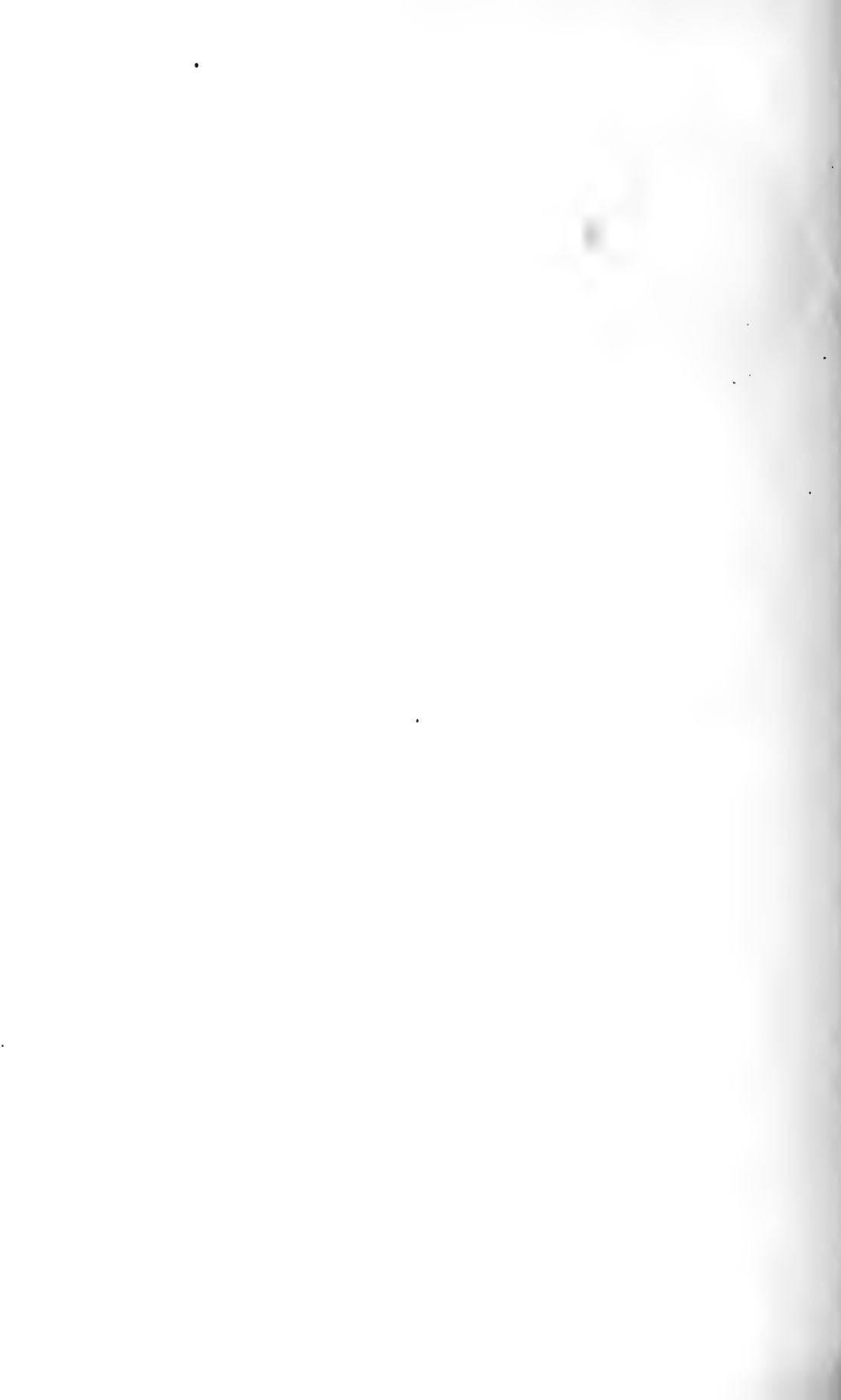
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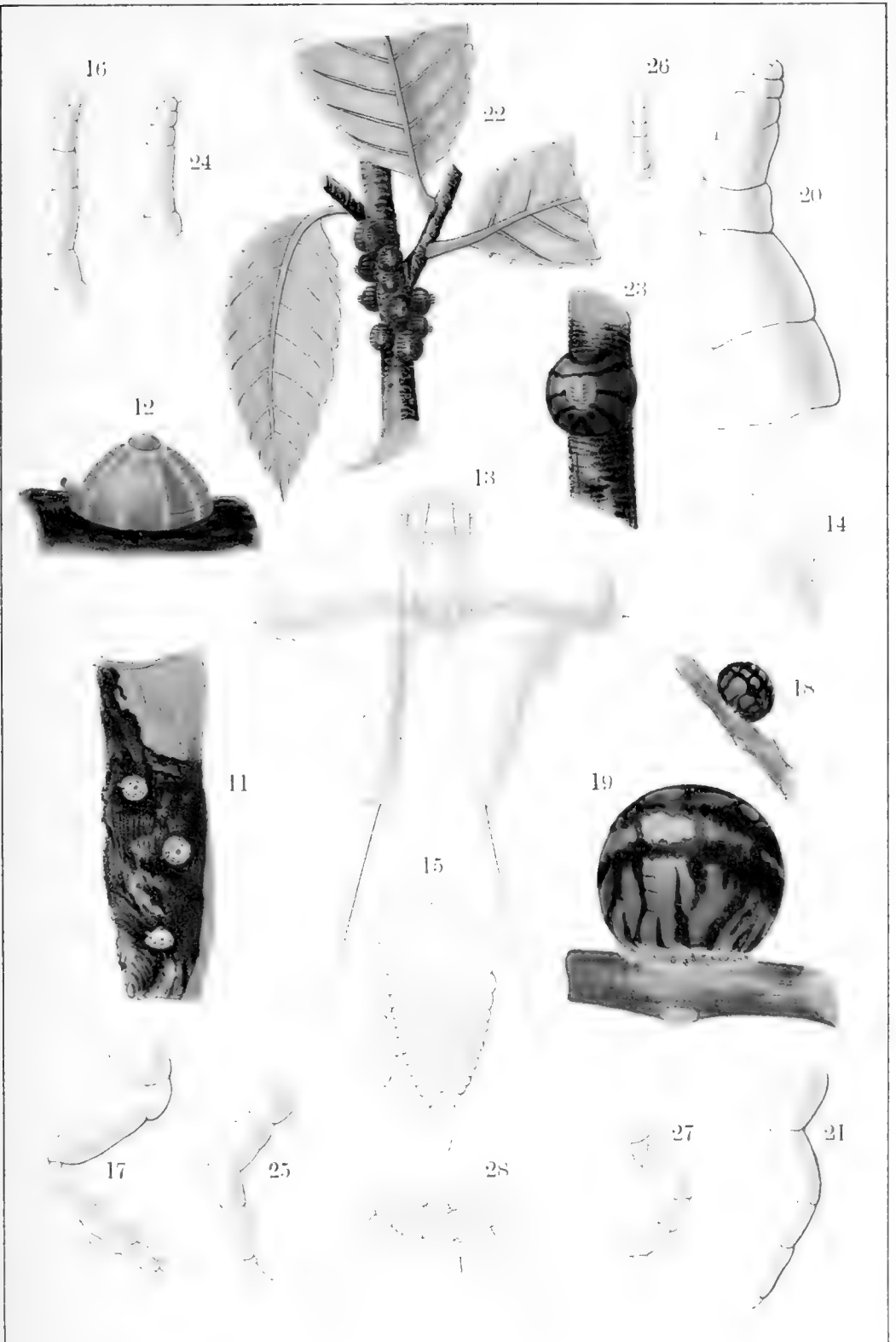
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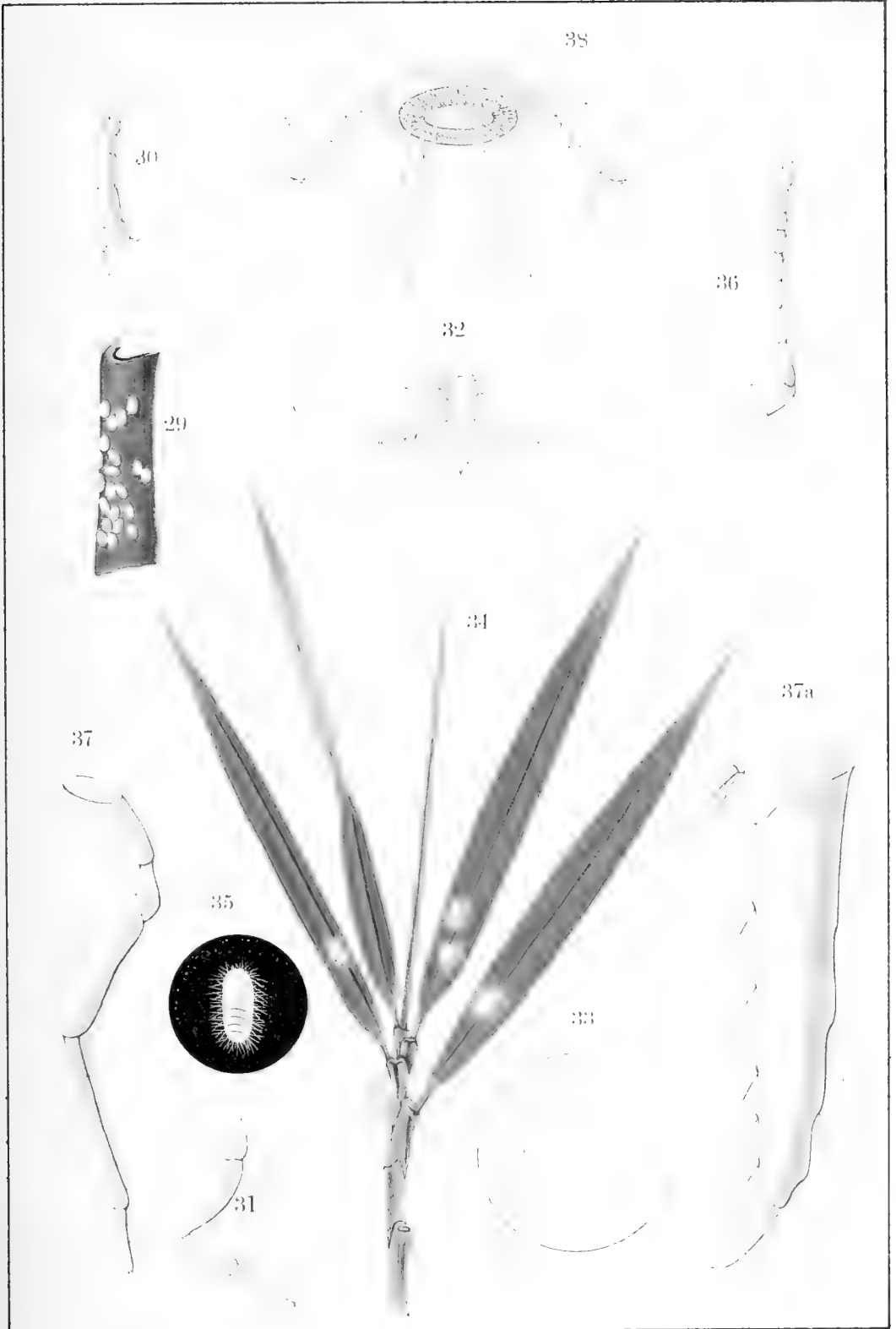
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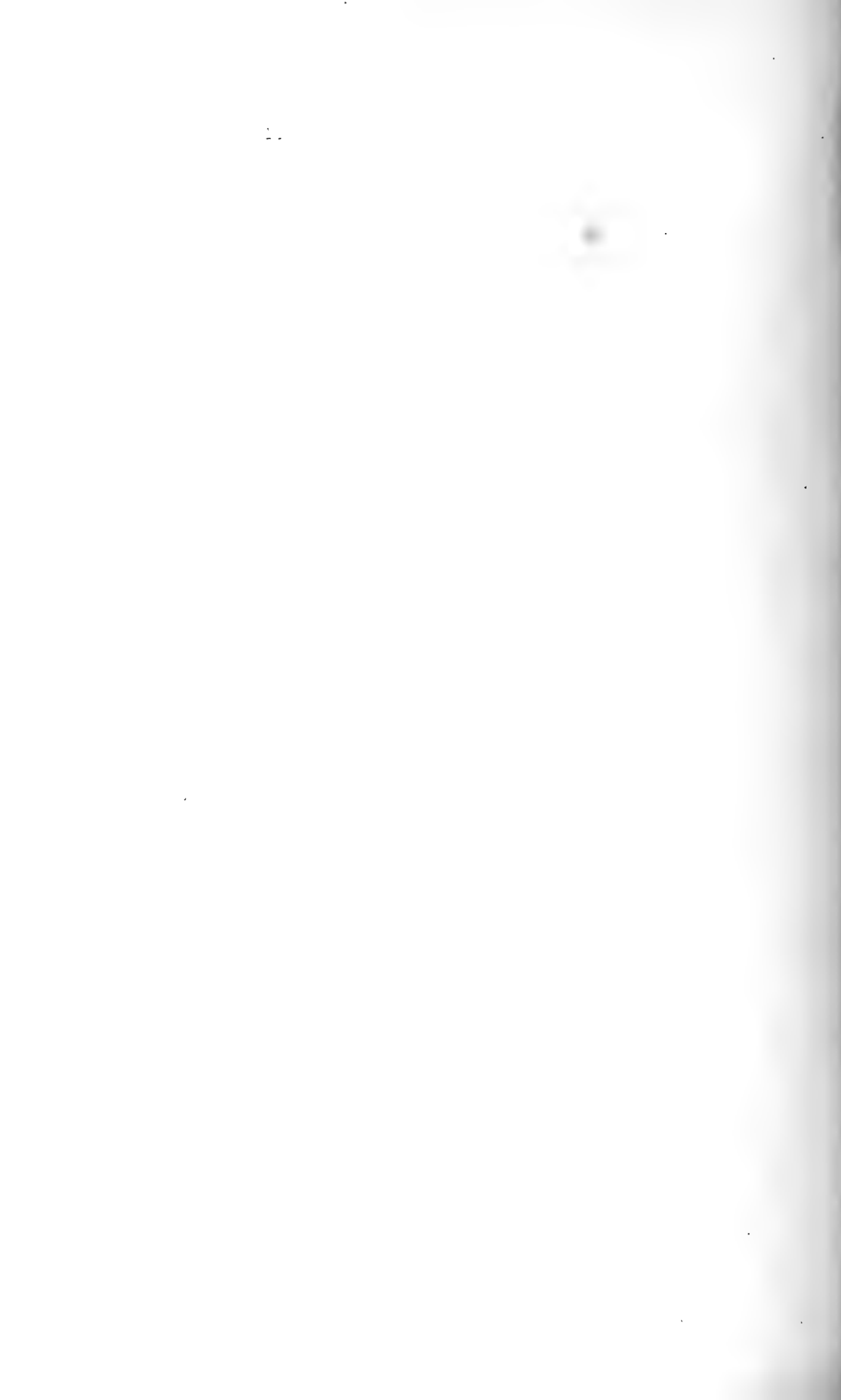


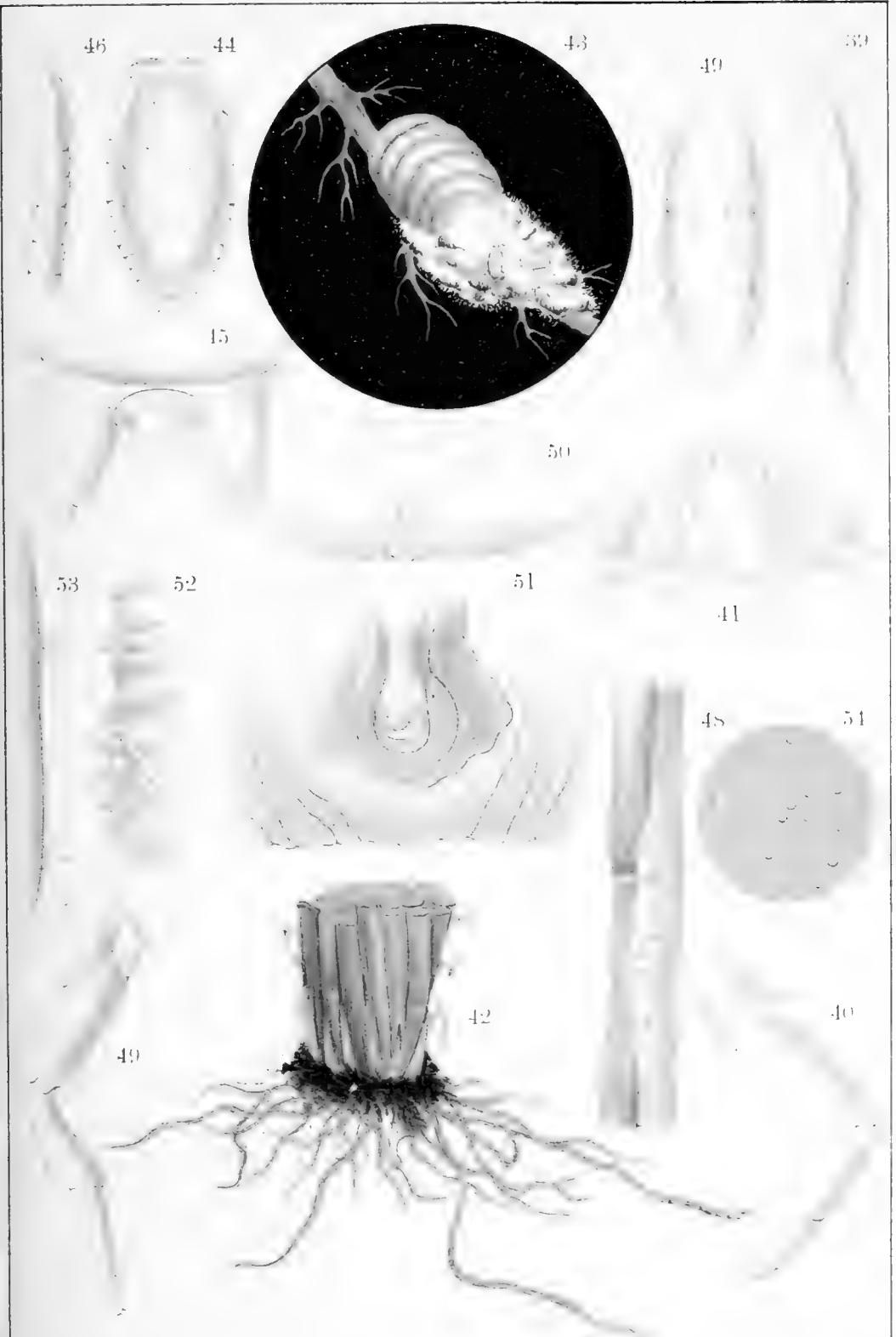




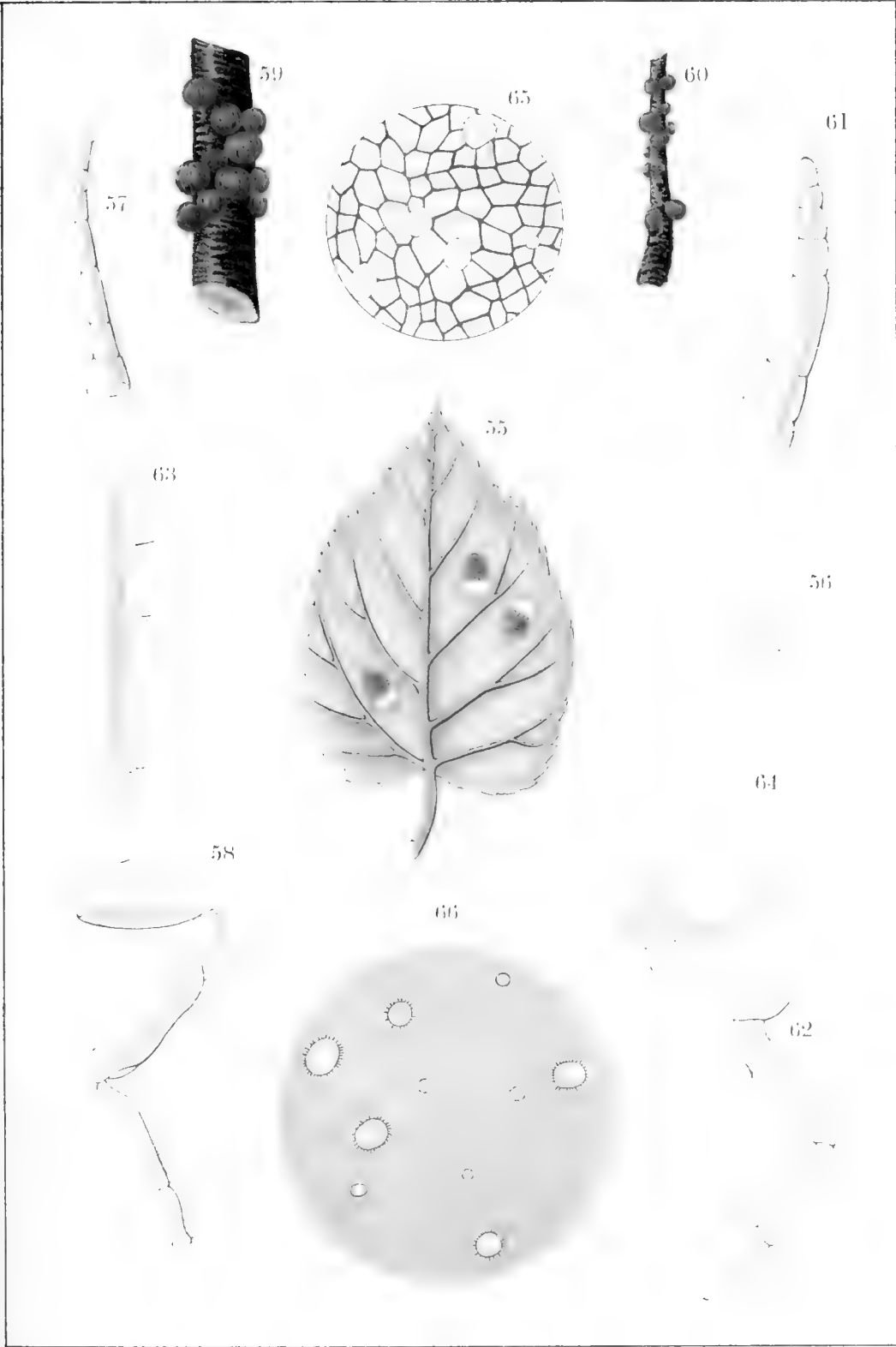


S. I. Kuwana & S. Tanaka del.



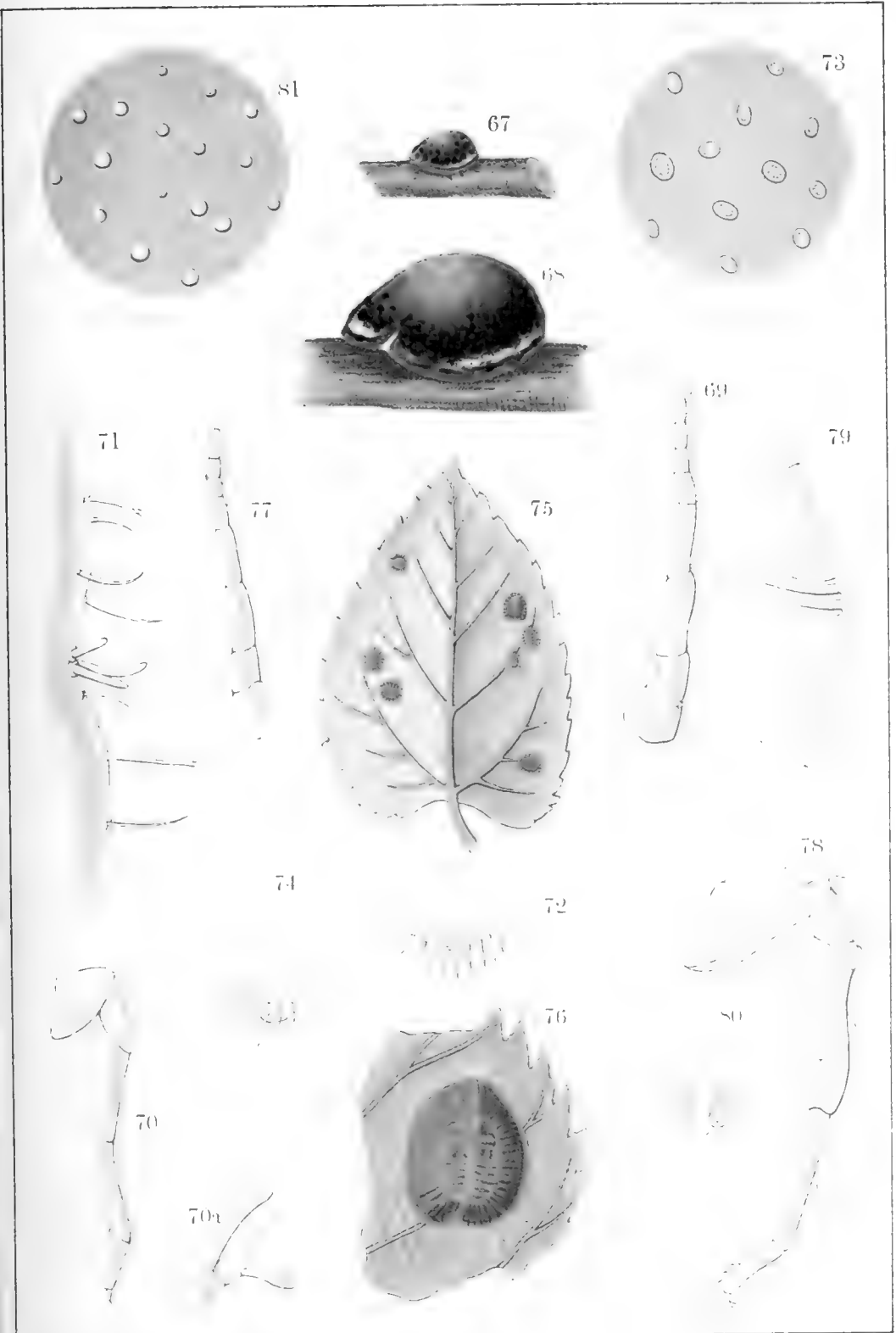














Coccidæ of Japan, II.

A New *Xylococcus* in Japan.

BY

S. I. Kuwana.

*XYLOCOCCUS MATSUMURAE* N. sp.

(Plate XXXIV, Figs. 1—13.)

*Egg*.:—Length 133  $\mu$ ., width 153  $\mu$ ., regularly oval in outline; shiny and of light orange color with two black spots near the anterior extremity.

*Newly hatched larva*.:—Length 189  $\mu$ ., width 117  $\mu$ ., across broadest part of the abdomen. Elliptical in form, slightly narrower anteriorly; the posterior end of the abdomen broadly round; segmentation distinct. Color light yellowish orange, the eyes dark purplish and very prominent. Antennae and legs very large, well formed.

*Antennae*.: Comparatively large, composed of seven segments; length about 91  $\mu$ .; segment 1 stoutest and broadest; segment 2 longest, but only slightly longer than 4 or 6; segment 5 shortest, and segment 3 and 7 subequal to 5; segments 6 and 7 bear a few fine hairs.

*Leg*.: Well developed; femur very large; tibia longer than tarsus; claw strong, slightly curved; digitules of tarsus long and fine hairs, longer than that of claw.

*Mouth parts*.: Very large, well chitinized; rostrum large, two segments; rostral loop very long.

*Abdomen*.: Composed of nine segments; last segment bears two long and two short spiny hairs.

*Adult female*.:—Length, about 4.5 mm., width about 2 mm. Elliptical in form, with anterior end slightly narrow, very prompt, distinctly seg-

mented. Color when living reddish brown; antennae and legs light brown. Antennae and legs are well developed but mouth parts are wanting.

*Antenna*: Length about 1 mm.; composed of 10 segments; segment 1 longest and broadest; next in length is 3, and then 2; segments 8, 9 and 10 subequal and shortest; formula; 1, 3, 2, 4, (5, 6, 7), (8, 9, 10); each segment bears a few spiny hairs.

*Legs*: Large and stout; three pairs alike; trochanter usual triangular in form, bears a long spiny hair; femur slightly longer than tibia; tibia much longer than tarsus; tarsal segment bears scaly marking as shown in the figure, a few spiny hairs on the inner margin; claw short and stout, slightly curved; tarsal digitules long, fine hairs, those of claw short and stout.

Abdominal end without hair; anal tube indistinct. The body is covered with many minute hairs, and many small round pores are scattered all over the surface of the body.

Quite active, but when ready to deposit eggs, crawls into some crevice or crack of bark and produces a cottony cushion on which the female rests and secretes a considerable amount of white cottony substance over its entire body.

*Adult male*:—Length about 2 mm., length of wings 1.5 mm., width of thorax about 1 mm. Abdomen brownish orange in color, thorax black, front of head dark, eyes dusky.

*Eye*: Large, prominent, faceted.

*Antennae*: Length about 2 mm.; slender; hairy; Composed of 9 segments; segment 1 shortest and stoutest, other segments subequal and deeply incised between segments; each segment bears a few fine hairs, while the last segment bears four prominent knobbed hairs.

*Legs*: Three pairs of legs are subequal, slender, hairy; tibia more than three times as long as tarsus; tarsus bears scaly marking, bears many strong spines in the inner margin; claw short and stout, slightly curved; digitules normal.

*Wing*: Cinereous, the costal space fuliginous, the veins blackish brown, a streak near the discoidal vein in front and a narrow oblique streak behind the vein, colorless. The surface of wing irregularly reticulated.

*Halterc*: Large, club-shaped; bearing fine stout hooks at the apex which are curved and enlarged at the tip.

*Abdomen*: Spindle in shape; style short, but comparatively stout, slightly curved; sexual organ very large. On the dorsal aspect of eighth segment there is a large hump on which are ten prominent tubes through which a white, silvery, waxy substance is secreted, which forms long threads, exceeding the abdomen in length.

*Habitat*:—The writer collected this species on the bark of trunk of pine-tree (*matsu*), at Sugamo, Tokyo, Japan, on May 20th 1903.

This new species of *Xylococcus* was carefully compared by the writer with other known species, but the shape of antennae of newly hatched larva and that of female are quite different from any of them. The shape of style of male is also remarkably different from the known species, hence the writer feels justified describing this Japanese insect as a new species.

Type in the entomological collection of the Imp. Agr. Exp. Sta.

Three species of the genus *Xylococcus* have been heretofore known, as they are recorded as coming from the following localities:

1. *Xylococcus betulae* Perg.  
Lake Superior, U. S. A.                      on birch.
2. *Xylococcus feliferus* Loew.  
Australia.                                      on *Tilia europaea*.  
   *T. grandifolia*.
3. *Xylococcus quercus* Ehrh.  
California, U. S. A.                           on *Quercus chrysalepis*.

*Bibliography of the Genus Xylococcus.*

*Xylococcus betulae* Perg.

1898. Pergande,—Bul. 18, N.S., U.S. Dept. Agr., PP. 18-19.

*Xylococcus filiferus* Leow.

1882. Leow,—Verh. z. b. Ges. Wien, pp. 271-274.

1882. Sign.—Bul. Soc. Ent. Fr., (6) ii, p. CLXXV.

1890. Maskell,—Ent. Mon. Mag., XXVI, P. 278.

1898. Hubbard,—Bul. 18, N.S., U.S. Dept. Ag., P. 17.

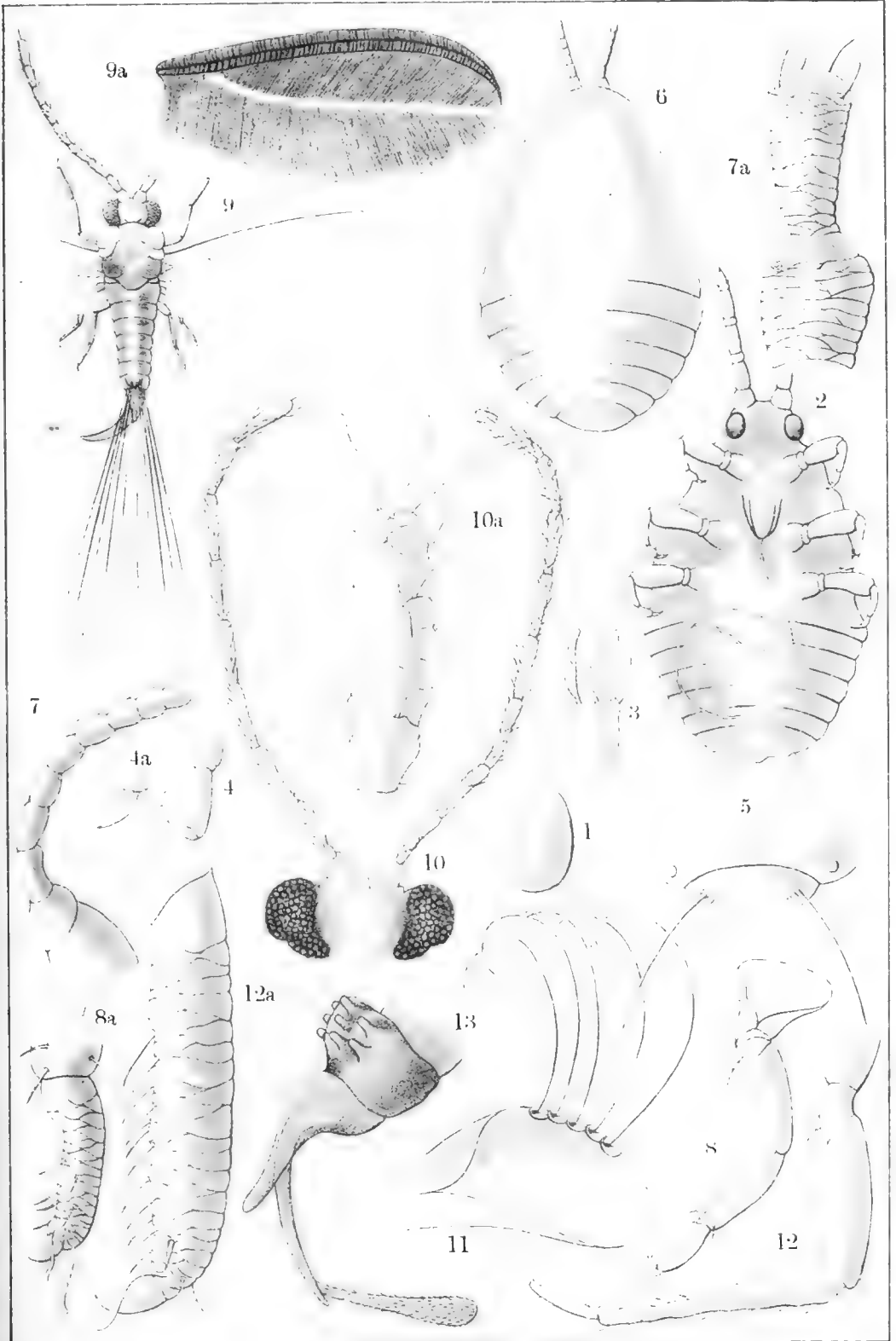
*Xylococcus quercus* Ehrh.

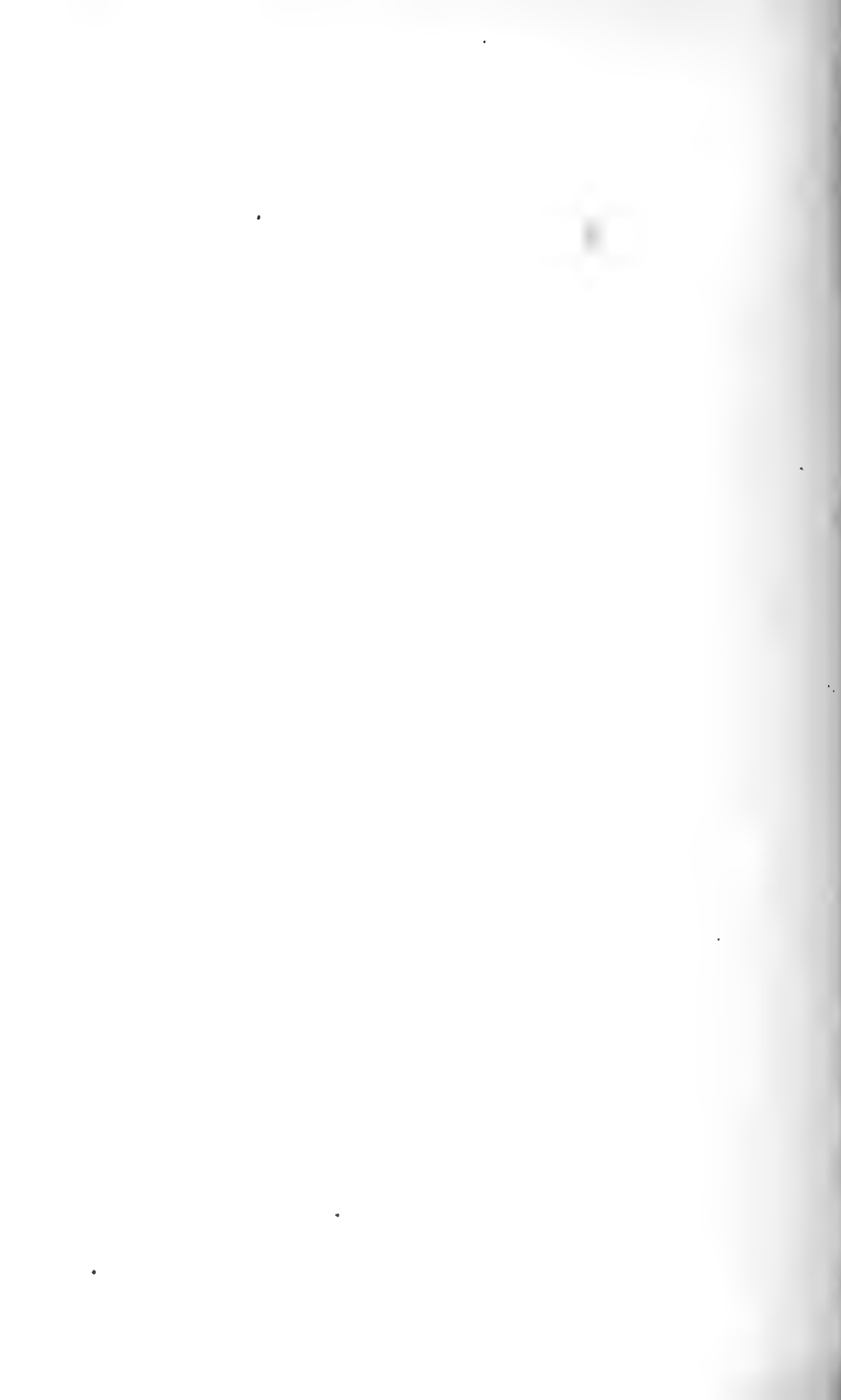
1900. Ehrh.—Canadian Entomologist xxxiii, p. 311.

## EXPLANATION OF PLATE XXXIV.

## XYLOCOCCUS MATSUMURAE N. Sp.

- Fig. 1. Egg. (z. AA  $\times$  4).  
 „ 2. Newly hatched larva, ventral aspect (z. I  $\times$  E).  
 „ 3. Last antennal segment of newly hatched larva (z. 2  $\times$  E).  
 „ 4. Leg of the same (z. I  $\times$  D); 4a, claw of the same (z. 4  $\times$  D).  
 „ 5. Last abdominal segment of the same (z. 2  $\times$  D).  
 „ 6. Adult female (greatly enlarged).  
 „ 7. Antennae of the same (z. 4  $\times$  AA); 7a, (greatly enlarged).  
 „ 8. Leg of the same (z. 4  $\times$  AA); 8a, tarsus of the same (z. 4  $\times$  D).  
 „ 9. Adult male (z. I  $\times$  AA); 9a, wing of the same (z. I  $\times$  AA).  
 „ 10. Head of the same (z. 3  $\times$  AA).  
 „ 11. Hind wing or Haltere of the same (greatly enlarged).  
 „ 12. Leg of the same (z. 4  $\times$  AA); tarsus (z. 3  $\times$  E).  
 „ 13. Last abdominal segment of the same (z. I  $\times$  E).







Notes on the Life History and Morphology of  
*Gossyperia ulmi* Geoff.

BY

S. I. Kuwana.

INTRODUCTION.\*

*Gossyperia ulmi* Geoff, the highly injurious elm bark-louse is a member of the subfamily *Coccinae* of the *Coccidae*, or Scale insects, and is a native of Europe. It was first found in France by Signoret\*\* who described it in 1875. It was first observed in America on the American elm (*Ulmus Americana*) in 1884, in West Chester county, New York. Again on the slippery elm (*Ulmus fulva*) at Cambridge, Mass., in 1887, where it was studied by John G. Jack. In 1888, it was found on the American elm on the grounds of the U. S. Department of Agriculture at Washington, D. C., and was studied to some extent by L. O. Haward, Entomologist of the Department.

The insect has been observed in two places west of the Mississippi River, viz at Carson city, Nevada, in 1895, and in 1894 on the campus of the Leland Stanford Jr. University near Palo Alto, California.

The spreading of the insect is easily brought about by the sending of

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\*The paper sets forth the result of a study of *Gossyperia ulmi* prosecuted by the writer, during the year 1899-1900, at the Leland Stanford Jr. University in California, U. S. A. At that time all the materials of study were obtained on the grounds of the University.

Since the writer returned to his native country (1902) he has learned that this insect has been discovered in the province of Shinano, and on the same kind of tree as he found it in California—an elm.

This paper is published to give in detail a description the particulars of such study. He regrets that he has been unable, because of inconvenience in obtaining materials, to study native specimens.

\*\* Signoret, Annales de la Société Entomologique de France for 1875.

young elm trees from infested nurseries, and so the insect is liable to become, in time, a serious and wide spread pest of the elms.

All notes which have been written on the life history of *Gossyperia ulmi* and the descriptions of the various stages, leave many points untouched. It is the object of this paper to present some additional information about the insect, especially with regard to its anatomy and post embryonic development.

The post embryonic development of the *Coccidae* presents some most interesting points, the great structural divergence of the male and female being accompanied by radical differences in the post embryonic development of the two sexes.

The female undergoes an incomplete metamorphosis, with interesting phenomena of loss of organs, while the male undergoes what may fairly be termed complete metamorphosis, with *histolysis* of certain larval organs, and *histogenesis* of imaginal organs from imaginal discs or histoblasts, processes as yet but imperfectly understood. (Diptera: a considerable study of these processes has been made in the more specialized insects like the Diptera).

#### I. GENERAL ACCOUNT OF THE LIFE-HISTORY AND HABITS.

The elm bark-louse (*Gossyperia ulmi*) has been found upon both American and cork elm trees on Leland Stanford Jr. University campus. The trees, especially the American elms were badly infested. This has given me an opportunity to make the following studies concerning the life history and habits of the insect.

The adult female produces a large number of young, from the beginning of June to about the middle of August. After the young have appeared the female becomes dry and dies.

The young are very minute objects, yellowish in color, and very active; as soon as they come out from the waxy cushion they crawl about on the tree. In a short time they molt and then go up to the small twigs and leaves, and are usually found on the underside of the leaves, near the middle veins; sometimes they are found on the upperside. Before the leaves fall they return to the twigs and large branches, or the trunk, otherwise they would fall to the

ground with the leaves and perish. Later in the season they are to be found in great numbers in the cracks of the bark and in the joints and around the dead scales where they have settled themselves to pass the winter.

The insects are more abundant near the middle portion of the tree, on the underside of the branches, and in sheltered places, and less on the tips or on the younger branches. The cracks in the bark of an old trunk are often full of dead insects. This insect, like other scale insects insert its long slender beak or buccle setae into the plant tissue and sucks the sap, and is one of the worst pests of the elm trees.

During the winter the larvae fasten themselves to the plants, being thinly covered with a white wax. They are inactive in cold weather, but on warm days, they may be seen crawling about. In the laboratory, they move about quite freely all winter.

The larvae reach the mature stage in the latter part of January. The first cocoons were found January 27, in the breeding cage; two days latter a number of cocoons were found on the underside of the limbs of some of the infested trees. Three days after the cocoons were seen, a grayish white projection was found at one end. This was the cast off skin of the larva, which had now changed to pupa. On February 2nd. the undersides of the limbs and branches were covered with white cocoons, which, from a short distance, gave them a snow white appearance.

The pupal stage lasts from seven to ten days. The adults first appeared on February 10th. Some of them had short thick wings, others had wings which covered three or four abdominal segments, while others had long transparant wings. The body was dark reddish and the antennae and legs pale. They were very active, but none of them, not even the long winged ones, had power to fly. The short winged ones predominated. Some had two long caudal filaments, while others had none.

The females and males mature at the same time, but the females do not make cocoons; they simply cast off their old, gray, waxy skin, which splits at the dorsal line. They are quite as active as the males. After copulation takes place, they move about for a while and then settle in a crack or on the underside of the large branches. The males soon disappear. The female

remains permanently fixed to the bark, secretes honey dew, increases in size, and becomes surrounded by a white marginal ring which consists of a white waxy material secreted by the developing insect. This waxy material arches over the back of the insect to which it is finally attached and curls inwards.

When a female is taken out from the cushion it seems to be a lifeless object, like a barley grain in shape, smooth, shiny, dark reddish on the dorsal aspect, and pale on the posterior extremity, while the ventral aspect is slightly covered with white wax. When turned over the feet move feebly. The young are born during the summer months and the life cycle is complete.

The manner of copulation.—When the insects have arrived to the mature stages, which is in February and March, they are quite active, roaming about on the branches. The male mounts the back of the female with its head in the same direction, bends its back a little, and also its long, bristle-like, genital appendages, towards the caudal extremity of the abdomen of the female and at the same time the abdominal segments of the female move rapidly up and down, and copulation takes place. This is usually accomplished in about ten minutes. The male lives only a short time after copulation; the female crawls about for a while, and finally settles in the cracks of the bark, on the trunk or large branches.

## 2. POST EMBRYONIC DEVELOPMENT FEMALE.

*Larva* (First stage).—The larva at birth is oval, flat, transparent, and yellowish in color; its length is about, 0.4 mm. and width about 0.15 mm.; the margin is finished with strong spines. The body consists of thirteen segments, not distinctly grouped into body regions. The skin shows hexagonal marking, and there are four rows of spines on the dorsal aspects.

*Head*:—The head is so flattened that the frontal portion is completely turned under, and appears as though it were a part of the ventral aspect. The dorsal aspect is somewhat crescent-shaped, with the anterior margin regularly curved, and the posterior end broadly jointed at the thorax. There are six marginal spines, on each side, and a row of four spines between the antennae.

The eyes are situated on the margin, at the extreme outer angles of the head, just behind the antennae; and are reddish in color.

The clypeus is an elongated triangle with the anterior margin straight and the sides very convex.

The antennae are composed of seven joints. The first is short and stout, the second longer but more slender, the third more than twice as long as the second and longest of all, the fourth, fifth and sixth are about equal in size, the seventh longer than the sixth and tapering towards the extremity, and somewhat irregular in outline. All segments have several prominent hairs. The length of the antennae is about 0.09 mm.

The labium, or beak is triangular in form, and consist of two segments. The sides of the labium are turned upward and inward, becoming almost united at the dorsal aspect so as to form a flattened conical sheath through which the buccal setae are thrust. The free tapering end is finished with a few spiny hairs. The buccal setae are four in number, enlarged at the basal end, and more than twice as long as the whole length of the body.

The chitinous framework of the mouth-parts in this stage shows a more prominent condition than in the adult female; the essential parts are the same, but in the adult female they are more strongly chitinized.

*Thorax* :—The thorax is very large, being the widest part of the body, and occupies more than one third of the entire length of the insect. The prothorax is smaller than the mesothorax, narrowing at the anterior end up to the head. The suture between the head and prothorax is indistinct but there is a slight constriction. There are three strong marginal spines on each side, and four on the dorsal aspects, the two middle ones being larger than the outer two.

The mesothorax is the largest segment of the thorax, wider than long, tapering slightly at both ends, with three marginal spines and four dorsal spines as in the prothorax.

The metathorax is smaller than the mesothorax, but larger than the prothorax, two marginal spines on each side, and four dorsal spines as in the mesothorax.

The legs are attached near the lateral margin of the thoracic segments.

They are equal in size and similar in structure, being rather stout and short. The coxa is large, and thick, a little longer than wide; the trachanter is a small triangular piece so closely united with the femur that it appears to be a part of the latter; the femur is the largest segment, wider than the tibia, tapering at both extremities; the tibia is less than one half the length of the femur and more slender; the tarsus consists of a single segment longer than the tibia, tapering toward the free end, and bears a pointed claw and four knobbed hairs.

The spiracles are four in number and simple. The anterior pair are situated on the ventral aspect of the prothorax, a short distance from the front legs; the second pair are located between mesothorax and metathorax. They are surrounded by a kidney shaped chitinous piece.

*Abdomen*:—The abdomen is composed of nine segments, tapering toward the free end; the first eight segments are alike except in size, the last or ninth is greatly modified being prolonged backwards at the sides; the posterior margin bears two long filaments and a few spines. Each abdominal segment has a strong marginal spine on each side and four on the dorsal aspect. The middle spines of the dorsal aspect on the first three abdominal segments are large and the others small. The spines on the side are small and all of the same size. The anal opening is provided with six hairs.

*Larva* (Second Stage).—After the first molt, the larvae become more or less oval in shape, with very distinct segments. The marginal and dorsal spines are lost, and the dorsal aspect is now covered with rather short spines, while the ventral aspect has a few small hairs. The length of the body is about 1 mm. width about 0.5 mm. across the thorax, and is dark reddish in color. The dorsal aspect is now furnished with wax ducts. The spines are about 0.03 mm. in length, yellowish in color, and covered with white wax. The legs and antennae show no apparent changes, except in size. The length of the antennae is about 0.14 mm.

When ready to molt again the length of the body is about 2 mm. and half as much in width at the thorax. Antennae is about 0.8 mm. in length and seven jointed. Up to this period the sexes resemble each other so closely in every respect that they are hardly distinguishable.

L. O. Howard says\* that the antenna of the newly hatched larva is six jointed, and of the full grown male larva is seven jointed, while the antenna of the full grown female is six segmented. It would seem by this that the different sexes can be distinguished by the characteristics of the antennae. According to my observation all stages have seven jointed antennae. Only in a few cases the antennae were six jointed.

*Adult* (Third Stage).—The adult female is oval, wingless, and spiny, and resembles, in general appearance, the immature stages. The body is about 1.5 mm. in length, and 0.6 mm. in width, color dark brown. Antennae and legs are somewhat faded. The cast off skin is grayish white.

After impregnation the body becomes very much enlarged and more rounded. Length of the body is than about 2.5 mm. width about 1.6 mm. The head and thorax together are about equal to one-half of the entire length of the insect, and the thoracic region is the widest. The structure of the head and its several points are not different from the larval condition. The mouth parts are about the same, but more chitinized. The antennae are about 0.25 mm. to 0.30 mm. in length, and consists of seven segments; the third and fourth are longest, the fifth and sixth shortest the seventh shorter than the fourth but almost as long as the fifth and sixth together. Each segment has a few prominent hairs. The hairs on the first segment are the shortest; the seventh has the longest hairs. The three pair of legs are similar in structure. They are slender and comparatively short. The abdomen occupies about half of the entire length of the body, tapering toward the posterior extremity. The ninth segment is modified by being prolonged at the sides backward, bearing a few spines and a long spiny hair at the extremity. The anal opening has six hairs.

#### MALE.

*Larva* (First and Second Stages).—The male in the first and second stages is like the female in the same stage.

*Cocoon of male*.—When the male larvae are full-grown each finds a suitable place and makes a cocoon. The cocoons are found in groups, usual-

\* Insect Life Vol. II., P. 36, 1889.

ly on stems or branches, and are particularly numerous near the stem or on the underside, where they are protected from sunshine and storms.

These cocoons give the branches a snow-white appearance, in patches of variable size. Some cocoons have a projecting mass at one end and some do not. This projecting mass is the cast off skin of the larva which is pushed out from the posterior end of the cocoon during pupation. In some cases this skin is left inside of the hinder part of the cocoon.

*Development of the pupa.*—Differing markedly from the female, the male undergoes, between its larval and adult stages, a distinct pupal stage; a stage wholly comparable to the pupal stage of insects with complete metamorphosis. There is a considerable breaking down or histolysis of larval organs and tissues, and a building up or histogenesis of imaginal organs from imaginal discs. The larval legs are replaced by imaginal legs which are wholly new organs and which begin their development (As imaginal discs in the body) during the larval life, and so with the other organs.

On examination of the male larva, just before the change takes place to pupa, (Fig. 1) no larval organs can be found, the body, except the head and thorax, being nothing more than a sack containing protoplasmic granules, and oil drops in a yellowish fluid. In the head and thorax there are five pairs of granular masses of cells in the ventral aspect, and a pair on the side of the mesothorax. These are the imaginal discs or buds (Fig. 1; img) from which new appendages develop. The pair of buds in the head, which form the eyes (Fig. 1, img 2), are larger, the other pair give rise to the antennae (Fig. 1; img 1); three pairs on the thorax, one on each segment, develops into legs (Fig. 1; img 3), one on each side of mesothorax, develops into wings (Fig. 1; img 4).

In studying these discs by means of sections, it is seen that these imaginal discs are made up of microscopic masses of indifferent cells which rise from the hypodermis during the larval growth.

The imaginal discs are gradually developed into elongated bodies, the wings discs extending beyond the body. About this time the pupa casts the last larval skin and pushes it out from the cocoon. This is "propupa stage" (Fig. 2) according to Prof. Riely. The propupa develops gradually,



the antennae and the legs become more elongated and divided into two parts, the wing pads more flattened (Fig. 3); and finally the antennae and legs become more slender, the antennae dividing into ten segments, the legs into five, and the dark eye spots appearing (Figs. 4, 5).

*Pupa* (Third stage).—Color of pupa is a blackish red, legs, antennae, and wing pads are pale and transparent; the eyes dark. The general shape is an elongated oval, resembling the larva. The antennae are pressed close to the side, reaching to the base of the wing pads. The wing pads are also pressed against the sides; they are elongated, and ovate in form, reaching to the second abdominal segment; the legs are short and rather stout; the first pair are thrust forward, while the other pairs extend downward. The abdominal segments are distinct, the anal end is pointed.

*Adult* or *Imago* (Fourth stage).—Up to the present time, it has not been made clear whether there are two kinds of males developed from different sorts of eggs, or whether the perfect males are those in which additional development and molting have occurred, or whether the varying males are developed from the same sort of eggs and vary among themselves. Dr. Howard\* thinks that there may have been a molt between the "Pseudomago" (the short winged form) and the perfect male, for by no other way can we account for the difference in form. Prof. G. H. Perkins\*\* thinks there is no molt between these two forms of males, but considers it probable that some differences in food, season, and climate effect the development of the insects; and that under some conditions imperfect males predominate, while under other conditions the perfect ones are more abundant. To investigate the matter, I kept some cocoons in a breeding cage. On February 10th. came out four specimens, three with short wings and one with long; the next day, there came out three with long and nine with small wings, varying from medium to short; the next day a great many emerged, those with short winged predominating. I separated them according to the difference in the size of the wing. They lived from two to three days, but I saw no signs of another molting. All of these different forms of males copulated freely.

\* *Insect Life* Vol. II. P. 38, 1889.

\*\* *Eleventh Vermont Agricultural Report*, P. 269, 1889-'90.

An examination of the short wing showed them to be thick, wrinkled and somewhat pale yellowish in color; those of medium size were thinner, not so wrinkled but still not perfect, while the wings of the perfect male were a little longer than the body, and very thin and transparent. Many of the short winged forms have no waxy filaments extending from the posterior end of the body, and then again many do, just as in the perfect males. Those without waxy filaments may possibly have lost them through breaking, or other causes. This experiment seems to show that Prof. Perkins' idea may be correct, that the difference in the males is caused by food, season, climate, or other circumstances which cannot be explained.

The body of the male is oval, flat, and stout, and very fleshy; 1.5 mm. in length, 0.35 mm. in width at the thoracic region. 2.6 mm. when wings are expanded; dark reddish in color; antennae and legs a pale yellow; wings transparent.

*Head*:—The head is nearly globular in form, slightly pointed in front. 0.15 mm. in length, 0.18 mm. in width. The cheeks are very large and globular forming the larger part of the head. There are a few short spiny hairs on the frontal region. Mouth parts are wanting.

The antennae are ten jointed, 0.5 mm. in length. The first segment is the shortest and is thick; the second large and globular; the third the longest; while the rest are equal in size; except the tenth, which tapers toward the apex. All segments are finished with long fine hairs.

The eyes are globular, prominent, and six in number. Two are on the dorsal aspect near the frontal margin, rather small and transparent, the two pairs on the ventral aspect are large and dark reddish in color.

*Thorax*:—The thorax is large and somewhat oblong; three thoracic segments are distinct. The prothorax is small and somewhat triangular in shape, much broader than long, and convex on the dorsal aspect, while the ventral aspect is rather flat. The mesothorax is the largest, somewhat angular in front and rounded at the posterior end. Sectulum and scutellum are distinct; former is very much broader than long, the latter is as long as wide and is convex, and triangular in shape. The muscles in this region are well developed. The metathorax is smaller than the mesothorax, but longer

than the prothorax. It is such wider than long, and is closely attached to the posterior end of the mesothorax.

The wings are thin and membranous; when folded on top of the body they are as long or longer than the entire length of the abdomen, with very minute hairs. The front margin is thick and nearly straight, except for a slight curve toward the free end; the posterior margin is curved very strongly. They are provided with two veins, subcostal and cubital; the former is longer and stronger than the latter, running parallel with the costal margin and disappearing gradually toward the external margin of the wings. The cubital is shorter and weaker and rises near the base of the subcostal, running abliquely, terminating about midway of the posterior margin.

The balancers are composed of two parts, a basalbristle, and a free end slightly curved.

The legs are long and slender and similar in size and structure. The coxa is large and stout, oval in shape; the trachanter is very short and small, closely attached to the femur, and is oblong in shape; the femur is long and stout; the tibia is long and slender, longer than the femur and trachanter combined, with two strong spines on the inner portion of the posterior end; the tarsus is about one fourth the length of the tibia, slightly tapering toward the extremity where it is terminated by a stout, movable, denticulated claw, and four knobbed hairs; two long ones are attached to the outside of the tarsus, a short distance from the extrimity, and two smaller ones to the base of the claw. Both extend a short distance beyond the tip of the claw.

*Abdomen*:—The abdomen is a little longer, but narrower than the thorax. It consists of nine segments; the first seven segments are similar in form, gradually tapering toward the free end. The eighth segment is modified slightly by being prolenged at the sides, backward. The dorsal aspect on each side is provided with a group of spinnerets. Two long spiny hairs project from the middle of each group, through which, the long waxy filament is sent out. In the ninth segment is found the penis, which consists of two long bristle-like appendages lying closely side by side so as to form a single long filament, which is placed in slender conical style.

## 3. ANATOMY.

The anatomy of a number of the species of *coccidæ* has been studied and described. (See the papers of List,<sup>1)</sup> Mark,<sup>2)</sup> Putnam<sup>3)</sup> and etc.)

The essential features of the anatomy seem to be the same in the different groups, but there is difference in detail of structure.

I have studied in some detail the anatomy of *Gossyparia ulmi*, chiefly using specimens in the second larval stage, as the thin body wall of this stage is more pervious to killing fluids than the thicker integument of the adult. Of the adult I have only attempted to describe the sexual organs and to refer briefly to other important points.

*The chitinous framework of the mouth parts*.—The pharynx and bases of the mouth parts are combined in a space between two somewhat five-sided planes, supported by a chitinous framework (Fig. 6). The lower plane, or *arca inferior* of Mark, is large; it is bounded on the front by the *arcus inferior*, on the side by the *castæ inferiores*, right and left, which appears to be composed of two parts (Fig. 6; b, n.), meeting at pint F. The posterior portion meets with the corresponding part of the *castæ superiores* to form the perforated clavus through which the buccal setae pass (Fig. 6; p.). The upper plane or *arca superior* is bounded by the *castæ superiores* right and left (Fig. 6; C.M.) which bend backward and downward to meet the *castæ inferiores* at e. The posterior portions of the *castæ superiores* (Fig. 6; m.) bend downward until they unite with a broad plate which unites with the *castæ inferiores* to form the clovus. At point f. and g. a branch d connects the *castæ superiores* and *inferiores*.

- 
- 1). Joseph H. List.—*Orthezia cataphrocta* show.  
Zeitschrift f. Miss. Zoologie Et. XIV.
  - 2). E. L. Mark.—*Beiträge zur Anatomie und Histologie der Pflanzenlaus, insbesondere der Coccidan.*  
Archiv f. Mikroskop Anatomie Bs. XIII, 1876.
  - 3). J. D. Putnam.—*Biological and other notes on Coccidae.*  
The Davenport Academie of N. S. Vol. II, 1879.
- Adolfo Targioni Tozzetti.—*Studi Sull: Cocciniglie.*  
Societa Italiana di Scienze Naturali, Tomo. III, N. 3, 1867.

From the middle of this branch, a chitinous process (Fig. 6; t.) extends inwards about two-fifths of the distance toward the center, and unites with an internal tube (Fig. 6; nt.) and helps to support it. The enlarged conical bases of the four buccal setae (Fig. 6; st.) are supported by this complicated framework. Each seta consists of a very long, slender, solid rod, or so called "tube," enlarged at the base, forming an elongated cone. The conical base is attached to the framework by strong muscles. In the lower pair of setae the cones are more elongated and more slender, while the upper ones are rapidly enlarged at the bases. The four setae meet at the clavus (Fig. 6; p.) and pass through it, forming a tube. This tube then passes into a long, pocket called the labial cavity, which lies in the body cavity (Fig. 7; la, C.) beneath the nervous system, and extends as far as the fourth or fifth abdominal segment. The tube fills the full length of this pocket and returns to where it entered, forming a long loop.

When in use, the tube is thrust through the labium. The internal part of the labium (Fig. 7; el, s.) seems to be modified to form a thin, transparent, elastic sack, through which the setae pass when in use. The setae are withdrawn by means of the elastic nature of the walls of the pocket. The pocket appears to be free in the cavity. Its walls (Fig. 8) consist of three layers, an outer thin layer (Fig. 8; au, l.), a thick middle layer (Fig. 8; mi, l.), and an inner layer (Fig. 8; in, l.) which is a weakly chitined membrane.

The buccal setae are furrowed their entire length, but are not hollow, as former writers have observed.<sup>1)</sup> They meet at the clavus to form a tube through which the sap of the plant is sucked up. Between the setae is a trumpet shaped, strong, chitinous tube (Fig. 6; nt.), which opens at the juncture of the four setae. This internal tube protects the buccal cavity and anterior part of the pharynx.

*Alimentary Canal*:—The alimentary canal begins as a narrow buccal cavity extending upward and widening to form the pharynx. The pharynx

1). Maskell.—An. account of New Zealand Scale-Insects, p. 9.

J. D. Putnam.—Proceeding of the Davenport Acad. N. S. Vol. II, p. 318.

is large and long with very thick wall; the posterior end being gradually narrowed and merged into the oesophagus (Fig. 9, oe.). The oesophagus is long and slender and extends slightly forward from the posterior end of the pharynx, then turned upward, passing outside of and around the *arcus superior*, and then backward extending into the thorax, there it becomes enlarged and is merged in the ventriculus (Fig. 9, ve.). The ventriculus extends backward a short distance and then turns abruptly forward making a few convolutions enclosed within the anterior part of the rectum (an extraordinary condition common to all of the *Coccidae* so far studied), and forms a very long and narrow intestine (Fig. 9; in.) extending backward nearly as far as the anus, and then forward to near the point of beginning where it joins the rectum. The rectum (Fig. 9; ri) is a long straight tube distended in the middle which extends backward from the posterior end of the intestine to the end of the anal opening.

*Malpighian tubes*:—A short distance from where the large intestine emerges from the anterior part of the rectum, arise the two Malpighian vessels (Fig. 9; mp.). They are fused at their bases to form a single tube which soon divides into two long tubes extending one on each side of the rectum.

*Salivary glands*:—There is single pair of salivary glands (Fig. 11; sa, g; 13), one gland laying on each side of the oesophagus. Each gland consists of a number of spherical lobes (Fig. 13; la.), more or less united. Each lobe consists of one or more nucleated cells, and each lobe gives rise to a small tube which unites with a larger one. This large tube unites with the one from the other side to form a common duct which opens into the mouth.

*Wax secreting glands of larva and adult female*:—The wax is secreted by minute spherical glands (Fig. 14) which are distributed on the dorsal aspect of the body (Figs. 11, 12; wg.) usually six to eight in each segment. Each gland consists of several nucleated cells with a slender straight tube or pore (Fig. 14; po.) which opens externally. This tube is chitinized, transparent, and enlarged at base where it rises from the gland.

*Wax gland of adult male*:—Two large ovel shaped wax glands are situated in the seventh and eighth abdominal segments of the adult male

(Figs. 15, 15a), one on each side of the alimentary canal. These glands furnish the material forming the long waxy filament.

*Respiratory organs* :—The spiracles are four in number as already described in the account of the external anatomy. These extend inward from each spiracle, a large tracheal tube (Fig. 16) which soon divides into many branches and subbranches, sending its ramifications to all parts of the body. There arise immediately the anterior spiracles two main branches and three small ones. One large branch extends toward the opposite side of the body, close to the ventral wall until it meets and unites with a corresponding branch from the opposite spiracle. The other large branch extends longitudinally toward the posterior end close to the ventral wall until it meets with a similar one from the posterior spiracle on the same side. A small branch extends to the antennae, while two others run forward into the head. From the posterior spiracles there extend five tracheal branches; one running forward to meet a similar branch from the anterior spiracle; another runs close to the ventral wall towards the opposite side to meet with a corresponding branch from the opposite spiracle; two other extend toward the posterior end, each giving out several branches which lie free in the abdomen; the fifth branch is smaller than the others, and extends laterally.

*Nervous system* :—The fusion of the nervous system (Fig. 17) is carried to such an extreme that there are but two large ganglia, one in the head and the other in the thoracic region. The supraoesophageal ganglion, or the cephalic ganglion (Fig. 17; s. o. g.) consists of two lobes which lie immediately in front of the mouth parts. From the anterior region of the cephalic ganglion proceed two large optic nerves (Fig. 17; op. n.) to the eyes; from the underside extend two small nerves to the antennae (Fig. 17; an. n.). From the posterior end is sent two commissures (Fig. 17; com.) backward, allowing the oesophagus to pass upward between them (Fig. 17; oes.); then they unite into one, passing between the *arcus superior* and *arcus inferior* and thence into the thorax. Here is situated the large, elongated thoracic ganglion (Fig. 17; tho. g.), tapering at each end. A longitudinal section (Fig. 17) shows that it consists of five ganglia fused

together. The cross section plainly shows a longitudinal division (Fig. 17 b). This single large thoracic ganglionic mass is composed of the fused suboesophageal ganglion (Fig. 17; in. o. g.), the three thoracic ganglia (Fig. 17; g. 1, 2, 3), and the most anterior abdominal ganglion (Fig. 17; a, b, g.). Each thoracic ganglion sends off a pair of branches, one from each side, which innervate the legs (Fig. 17; l. n.). Two large nerve cords extend from the posterior end of the abdominal ganglion, each of these sending of two branches outward and backward, free in the abdomen.

*The circulatory system or Heart*:—I have seen no traces of a dorsal vessel or heart.

*Muscular system*:—The muscular system consists of numerous distinct straight fibres (Fig. 18 b), which remain separate from each other. The muscles of the thoracic region (Fig. 18) are very much complicated, while in the abdomen, there are two sheets of muscles, one on the dorsal aspect, and the other on the ventral aspect of the body. The dorsal sheet is made up of six bundles, three on each side of the middle line of the body, and there are seven bundles in the ventral sheet. They are paralld to each other and jointed at each segment.

*Reproductive organs of larva*:—In the young female larva the reproductive organs (Fig. 19) are two large, elongated ovaries (Fig. 19; ov.), situated one on each side of the abdominal cavity. From the posterior end of each of these extend two oviducts (Fig. 19; ovd.) about equal in diameter to the ovaries, which unite into a common duct (Fig. 19; c. ovd.).

*The reproductive organs of the male larva* have not yet been examined.

*Reproductive organs of the adult female*:—The ovaries (Fig. 20) of the adult female are two in number. Each consists of many oval shaped, bulb-like ovarial tubes (Fig. 20; o. v. t.), each of which opens into the oviduct by a short broad tube. The oviducts (Fig. 20; ovd.) become united to form a common oviduct (Fig. 20; c. ovd.) which ends at the vagina (Fig. 20; va.). The spermatheca is a large sac-like organ which arises from the common oviduct near the vagina (Fig. 20 b, spe.).

*Reproductive organs of the adult male*:—The reproductive organs of the adult male consist of two large oval shaped testes (Fig. 21; ts.).



tapering at each end, which are situated in the fifth and sixth abdominal segments, one on each side of the alimentary canal. The vas deferens arises from the posterior end of the testes (Fig. 21; vas.). They unite to form a common duct—the ejaculatory duct (Fig. 21; eja.). The terminal portion of the ejaculatory duct is covered with a strong chitinous membrane, forming the penis, or intromittent organ. The lower end of the seminal ducts are slightly enlarged to form the seminal vesicle (Fig. 21; sev.).

*Spermatozoa*.—The spermatozoa (Fig. 21 a) are long and thread-like, slightly enlarged at one end, about 0.32 mm. in length and are grouped into bundles.

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## EXPLANATION OF PLATES.

## PLATE XXXV.

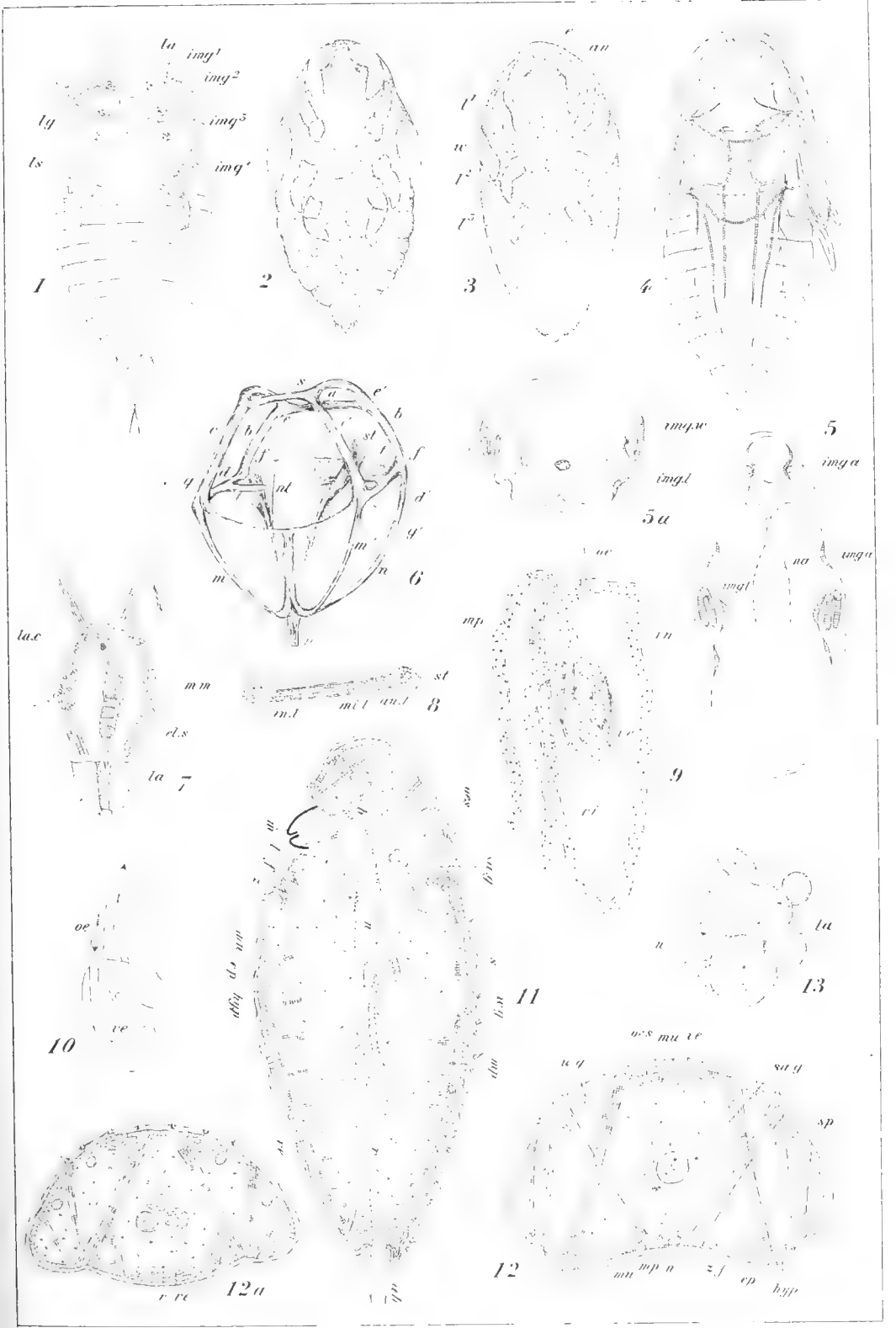
- Fig. 1. Male larva, just before change to propupa.  
img ; imaginal descs ; img<sup>1</sup>, antennae ; img<sup>2</sup>, eye ; img<sup>3</sup>, leg ; img<sup>4</sup>, wing ; l.s, larval skin ; lg, larval leg ; la, larval antenna.
- Fig. 2. Pupa (or propupa).  
an, antenna ; e, eye ; w, wing ; l<sup>1,2,3</sup>, legs.
- Fig. 3. The same with Fig. 2, more advanced stage.
- Fig. 4. Pupa, nearly full grown, showing the internal structure.
- Fig. 5. Pupa, longitudinal section ; 5a, cross section, na, nervous system ; img. l, imaginal desc of leg ; img. w, imaginal desc of wing ; img. a, imaginal desc of antenna.
- Fig. 6. Mouth parts and chitinous framework supporting them. a, aceus inferior ; s, aceus superior, b.p. casta inferior ; c.m. casta superior ; d, a branch which connecting the castae superiores and inferiores ; st, buccal seta ; t, a chitinous process ; nt, internal tube.
- Fig. 7. Longitudinal section of mouth-parts of larva and labial cavity with buccal setae.  
mm, muscles of mouth parts ; la. c, labial cavity ; el.s, elastic sack of labium ; la, labium.
- Fig. 8. Cross section of labial cavity.  
st, buccal setae ; au. l, outer layer, mi.l, middle layer ; in. l, inner layer.
- Fig. 9. Alimentary canal.  
oe, oesophagus ; ve, ventriculus ; ri, rectum ; in, intestine ; mp, Malpighian tube.
- Fig. 10. Diagram of the ventriculus, showing the convolution.
- Fig. 11. Longitudinal section of larva, (second stage) ; Fig. 12, Cross section of thoracic region ; Fig. 12 a, Cross section of abdominal region.  
sp, spine ; ep, epidermis ; hyp, hypodermis ; sa. g, salivary gland ; w.g, wax gland ; oes, oesophagus ; ve, ventriculus ;

r, rectum; re, reproductive organ; mp, Malpighian tube; n, nervous; z, leucocytes; f, fat bodies; mu, muscles.

PLATE XXXVI.

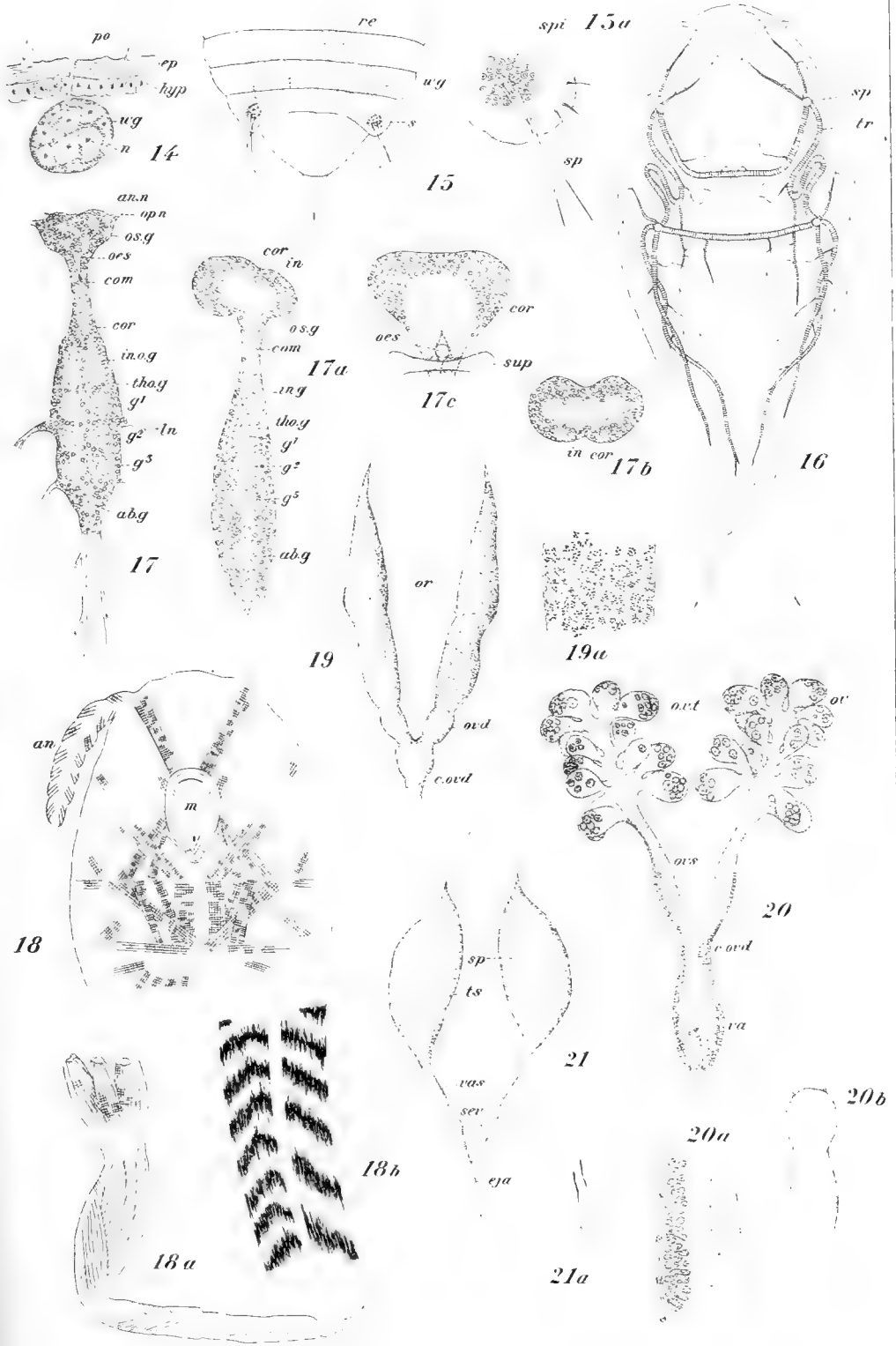
- Fig. 13. Salivary gland of larva.  
la, one of the lobes; n, nuclea.
- Fig. 14. Wax gland of larva.  
ep, epidermis; po, pore of wax gland; Hyp, hypodermis; wg, wax gland. n, nuclea.
- Fig. 15; Fig. 15 a. Wax gland of male.  
spi, spinnerets; w,g, wax duct; sp, spine; re, reproductive organ.
- Fig. 16. Respiratory system of larva.  
tr, trachea; sp, spiracle.
- Fig. 17. Nervous system: 17, Horizontal section; 17a, Longitudinal section, 17b, Cross section of brain, 17c, Horizontal section of brain.  
s.o. g, supraoesophageal ganglion; sp, n, optic nerves; an. n, antennal nerves; com; commissures; oes, oesophagus; in, o, g, infra oesophageal ganglion; g.<sup>1,2,3</sup>, thoracic ganglion; ab. g, abdominal ganglion; cor. ganglion cell; in, nerves fiber.
- Fig. 18. Muscle system of thoracic region of larva; Fig. 18a, Muscle of leg; Fig. 18b. Bundles of muscles showing the striae.
- Fig. 19. Reproductive organ of larva; Fig. 19a, Part of ovary, showing somewhat hexagonal cells.  
ov, ovary; ovd, oviduct; c. ovd, common oviduct.
- Fig. 20. Female reproductive organ; Fig. 20a, Wall of common oviduct; Fig. 20b, spe. Spermatheca.  
ov, ovary; o.v.t, ovarian tube; ovd, oviduct; c. ovd, common oviduct; va, vagina.
- Fig. 21. Male reproductive organ; Fig. 21a, Spermatozoa. ts, testes; eja, ejaculatory duct; sev. seminal vesicle; sp, spermatozoa; vas, vas deferens.





S. I. Kucania del.









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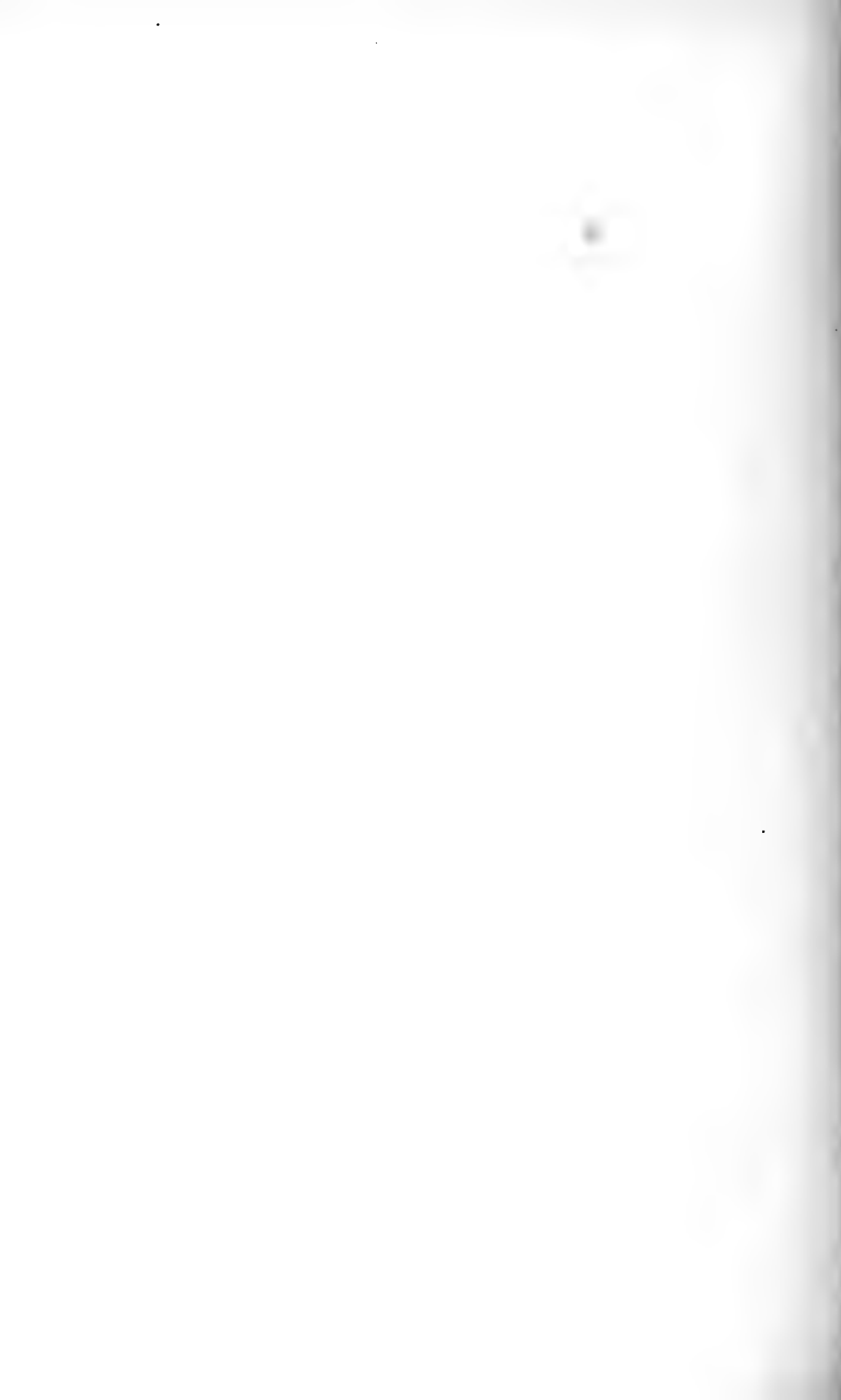
# 農事試驗場

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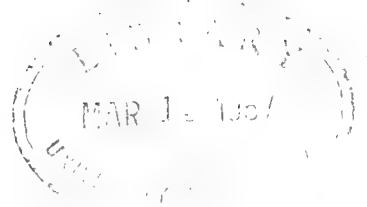


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Vol. II. No. I.



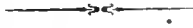
NISHIGAHARA, TOKIO.

MARCH, 1914.



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NISHIGAHARA, TOKIO.

MARCH, 1914



# Ueber saure Mineralböden.<sup>1)</sup>

VON

G. DAIKUHARA.

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## EINLEITUNG.

Seit langem ist es bekannt, dass viele Böden eine saure Reaktion auf Lackmus zeigen, und man führte dies meistens mit Recht auf die vorhandenen Humussäuren zurück. In anderen Fällen liess sich nachweisen, dass die saure Reaktion von der Oxydation von kleinen Teilchen Schwefelkies oder von der fortgesetzten Anwendung gewisser Düngesalze, vor allem  $(\text{NH}_4)_2\text{SO}_4$ ,  $\text{K}_2\text{SO}_4$ , &c. (der sogenannten *physiologisch sauren* Salze), auf kalkarmen Böden herrührte. Manchmal wird die saure Reaktion des Bodens durch saure Dämpfe von Vulkanen erzeugt<sup>2)</sup>, oder saure heisse Quellen, oder durch das erste Gärungsstadium organischer Düngemittel,<sup>3)</sup> wie Gründüngung, Stroh, Oelkuchen, jungen Stallmist etc.

Manche kolloidale Substanzen absorbieren hauptsächlich die positiven Ionen und setzen dadurch die Säuren vorhandener Salze und, wenn auch in geringem Masse, diejenigen neutraler Salze in Freiheit. Zu kolloidalen Substanzen der genannten Eigenschaft gehören die Humussubstanzen in der Ackererde, ferner Kieselsäuregel, kolloide Tone u.s.w., wie *van Bemmelen* u. A. vielfach durch ihre Untersuchungen bewiesen haben.

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1) Vorläufige Mitteilung dieses Artikels von Prof. Dr. Y. Kozai: Chem. Zeitung. 1908, 98, 1189.

2) W. Maxwell beobachtete z. B., dass der aus den Rissen des Vulkans *Kilauea*, Hawaii, aufsteigende Dampf 4.92% Schwefelsäure, aber keine Spur Salzsäure enthält. (Rept. of Work of Expt. Stat. of the Hawaiian Sugar Planters Association, Special Bulletin, A. 1905, 10.)

3) *Takaishi*, *Tuzaki* u. *Imai* hatten in Tokio beobachtet, dass im ersten Stadium der Gärung des Sojabohnen-Kuchens und anderen Gründüngers (*Astragalus lotoides*), Ameisensäure, Essigsäure und etwas Milchsäure entstanden.

*Ramann*<sup>1)</sup> nennt die bisher als „saure Böden“ bezeichneten „absorptiv ungesättigte Böden“ und führt weiterhin aus: „Es sind Böden humider Gebiete, reich an Humus oder kolloidem Ton, die gebläutes Lackmuspapier röten und aus den Lösungen von Neutralsalzen wechselnde Mengen von Säuren frei machen.“ Diese Behauptung ist aber nicht ganz den Tatsachen entsprechend, wie der Verfasser durch seine Untersuchungen beweisen kann, und über deren Resultate er im Nachfolgenden berichten wird.

Es gibt noch einen allgemeinen Fall, der bisher nicht beschrieben,<sup>2)</sup> und der vom Verfasser einem eingehenden Studium unterworfen wurde. In manchen Böden ist nämlich eine gewisse Menge durch kolloide Substanzen absorbierter Tonerde- bzw. Eisenverbindungen vorhanden, die beide auf Lackmus sauer reagieren.

Werden solche Böden, welche frei von Humus sind, mit Wasser gewaschen, so bleibt die Acidität völlig erhalten, nichts davon geht in Lösung über. Wird aber eine neutrale Salzlösung, wie z. B. KCl, K<sub>2</sub>SO<sub>4</sub>, KNO<sub>3</sub>, NaCl &c. zugesetzt, so kann sofort eine saure Reaktion der Lösung nachgewiesen werden. Zugleich lässt sich in dieser Lösung Tonerde resp. Eisen nachweisen. Ein solcher Boden gibt deshalb nach Düngung mit neutralen Kalium- bzw. Ammoniumsalzen einen noch schlechteren Ertrag als ohne Kalium- oder ohne Ammoniumsalze.

Zahlreich sind die Beobachtungen über saure Böden in Nordamerika<sup>3)</sup>, und die Vermutung, dass nicht immer Humussäuren dieser Reaktion zu Grunde liegen, sondern sauer reagierende, durch Kolloide absorbierte Tonerde- und Eisen-Verbindungen, dürfte sich wohl in vielen Fällen bestätigen.

1) *E. Ramann*: Bodenkunde 3. Aufl. S. 242.

2) *W. Detmer* (Landw. Versuchsstationen, 14, 277) und *Hübner* (Schulze, Lehrbuch d. Chemie für Landwirte, vierte Auflage, 588-589) beobachteten indessen eine saure Reaktion in manchen sandigen Böden.

3) *Rhode-Island* (*H. J. Wheeler*: 6th, 8th, 9th and 13th Ann. Repts. Agric. Expt. Stat. Rhode-Island), *Florida* (*A. W. Blair* and *E. J. Macy*: Fl. Expt. Stat. Bull. 93, 1908.), *Oregon* (*A. W. Shaw*: Oreg. Expt. Stat. Rept. 1898, 38-55), *Ohio*. (*C. E. Thorne*: Expt. Stat. Rec. XXII. 2,330), *Wisconsin* (*Science*, 1907, 412) etc.



Der Verfasser hat zum ersten Mal ein Interesse an der Reaktion des Bodens genommen, als er im Jahre 1907 einen Kalidüngungs-Versuch an drei verschiedenen Böden mit Gerste ausgeführt hatte.

Während zwei Tonböden einen guten Erfolg der Düngung ergeben hatten, zeigte ein Granitsandboden aus *Sumiyoshi* bei *Kobe* eine sonderbare Erscheinung. Die Keime kamen nicht zur Entwicklung, und wiederholtes Säen hatte keinen besseren Erfolg. Zuletzt aber wurde mit Roggen ein schwaches Wachstum erzielt. Es war hierbei sehr auffallend, dass die Zinktöpfe, welche diesen Sandboden enthielten und mit  $(\text{NH}_4)_2\text{SO}_4$ ,  $\text{Na}_2\text{HPO}_4$  und  $\text{KCl}$  gedüngt waren, allmählich angegriffen und zuletzt an verschiedenen Stellen durchlöchert wurden. Derselbe sandige Boden wurde zufällig für andere Versuche gebraucht, in dem der Verfasser folgende sonderbare Kalkwirkung beobachtete :

	Durchschnittliche Ernte per Topf in g.			Proportions- Ernte
	Körner	Stroh	Gesamt- Ernte	
a) Ohne Dünger. ... ..	0	2.45	2.45	3.0
b) Mit $(\text{NH}_4)_2\text{SO}_4$ , $\text{Na}_2\text{HPO}_4$ u. $\text{KCl}$ ...	0	0.48	0.48	0.6
c) Mit dito + $\text{CaCO}_3$	27.10	54.51	81.70	100.0

Das obige Resultat zeigt nicht nur die enorme Wirkung des Kalks, sondern auch die sehr schädliche Wirkung des salzigen Düngers in diesem Boden. Die weitere Prüfung ergab nun, dass dieser Boden eine starke saure Reaktion hatte, trotzdem er sehr arm an Humus war. Daraufhin untersuchte der Verfasser noch andere zahlreiche Böden und fand die Vermutung bestätigt, dass es in Japan und Korea viele solcher saurer Böden gibt, wie folgende Tabellen zeigen.

(Siehe die Tabellen auf S. 4 u.f.)

Es ist auffallend, dass 80–93% der geprüften japanischen Böden und 78% der geprüften koreanischen Böden eine saure Reaktion hatten, und dass von diesen Böden über 50% (japanische Böden 51–66%, koreanische Böden 64%) mindestens zum Teil ihre Acidität den, durch Kolloide

absorbierten Tonerde- oder Eisenverbindungen verdanken, während chinesische, südoceanische und europäische Böden nur wenig oder gar keine saure Reaktion zeigen. Dieser grosse Unterschied wurde wahrscheinlich durch die Verschiedenheiten geologischer Gestaltung, des Klimas und der Düngemittel hervorgerufen.

Reaktion des Bodens auf Lackmus-Papier.

Länder	Bodenarten	Zahl der Bodenprüfungen	Saure Böden				Böden		Prozente der sauren Böden
			Stark	Mässig	Schwach	Summe	Neutral	Alkalisch	
Japan	Jungfräuliche Böden	917	97	243	398	738 <sup>1)</sup>	169	10 <sup>2)</sup>	80
	Feldeböden	167	55	70	31	156	6	5	93
Korea	Jungfräul. Böden	162	7	74	45	126	16	20	78
China	Jungfräul. Böden	19	0	2	0	2	2	15	11
Java u. Philippin.	Feldeböden	13	0	0	0	0	10	3	0
Europa <sup>3)</sup>	Feldeböden	25	0	0	3	3	6	16	12

1) Nur in zwei Fällen beobachtete der Verfasser, dass die Acidität auf saurem Sulphat beruhte.

2) Diese alkalischen Böden kamen alle von den *Liu-choo* Inseln, welche Korallen ihren Ursprung verdanken.

3) Die untersuchten Böden sind dem Museum des landw. chem. Instituts der kaiserl. Universität Tokio entnommen; davon stammen 11 aus Belgien, 6 aus Deutschland, 2 aus Oesterreich, 3 aus Italien und 3 aus der Schweiz.

Der Verfasser hatte Gelegenheit gehabt, in der landw. Hochschule zu Berlin Böden aus Schlesien und Deutsch-Ostafrika zu untersuchen. Er fand, dass es unter diesen Böden auch viele saure gab, die sich genau so verhalten wie die japanischen sauren Böden, eine Tatsache, welche die folgende Tabelle illustriert:

Länder	Zahl d. Bodenprüfungen	Saure Böden				Böden		Proz. der sauren Böden
		Stark	Mässig	Schwach	Summe	Neutral	Alkalisch	
Schlesien ... ..	142	26	29	18	73	0	69	51.4
Deutsch-Ostafrika	73	12	30	12	54	18	1	74.0

Bei den meisten dieser sauren Böden tritt durch den Zusatz irgend einer neutralen Salzlösung sofort eine saure Reaktion in der il erstehenden Flüssigkeit ein; zugleich lässt sich in derselben Tonerde bezw. Eisen nachweisen.

Die Reaktion des Extraktes nach Zusatz einer neutralen  
Kalisalzlösung zu dem Boden.<sup>1)</sup>

Länder	Boden	Zahl der Bodenprüfungen	Saure Böden				Boden		Prozente der sauren Böden
			Stark	Mässig	Schwach	Summe	Neutral	Alkalisch	
<i>Japan</i>	jungfräuliche Böden	917	275	96	96	467	440	10	51
	Feldböden	167	38	46	27	111	51	5	66
<i>Korea</i>	jungfräuliche Böden	162	25	43	36	104	38	20	64
<i>China</i>	jungfräul. Böden	19	0	2	0	2	2	15	11
<i>Java u. Philippin.</i>	Feldböden	13	0	0	0	0	10	3	0
<i>Europa</i>	Feldböden	25	0	1	2	3	6	16	12

Weiter hat der Verfasser die Verbreitung des sauren Bodens in verschiedenen geologischen Formationen in Japan untersucht, mit folgendem Resultat :

Geologische Formationen	Zahl der Bodenprüfungen	Saure Böden					
		Auf Lackmus Papier.		Nach Behandlung mit K-Salzlösung			
		Zahl	Prozent %	Zahl	Prozent %		
Paläozoische ... ..	31	27	87	17	55		
Mesozoische... ..	27	26	96	21	78		
Neozoische	Tertiär... ..	129	107	83	94	73	
	Quartär	Diluv.	170	147	86	82	48
		Alluv.	307	224	78	120	39

1) Ueber die Reaktion des Extraktes nach Zusatz der neutralen Salzlösungen auf den Boden siehe nächstes Kapitel: „Bestimmung der Bodenacidität.“

So finden wir im allgemeinen mehr saure Böden in älteren Formationen, besonders solche, die nach Behandlung mit neutralen Kaliumsalzlösungen sauer reagieren.

Weiterhin wurde ein grosser Unterschied im Prozentsatz der sauren Böden aus sogenannten sauren und basischen Gesteinen, sowie der Böden aus vulkanischer Asche und Lava gefunden, wie folgende Tabelle zeigt:

Art des Mutter- Gesteins	Zahl der Bodenprüfungen		Zahl der sauren Böden		Prozent der sauren Böden	
	<i>Japan</i>	<i>Korea</i>	<i>Japan</i>	<i>Korea</i>	<i>Japan</i>	<i>Korea</i>
Saure Gesteine ... ..	96	41	65	38	68	93
Basische Gesteine ... ..	72	11	36	8	50	73
Lava und Asche ... ..	55	—	12	—	22	—

Es ist leicht erklärlich, dass von kieselsäurereichen, sauren Gesteinen stammende Böden zu einem grösseren Prozentsatz saure Reaktion zeigen, als die von basischen Gesteinen stammenden, und dass die aus recenter, noch nicht stark verwitterter Lava und Asche gebildeten Böden den mindesten Prozentsatz ergeben.

Der Verfasser hat dann die Eigenschaften und den Ursprung der Acidität des Bodens, den Nachweis und die Bestimmung der aus die durch kolloide absorbierten Tonerde- resp. Eisenverbindung stammenden Bodenacidität und die Beziehungen zwischen saurem Boden und Kalkfaktor untersucht. Das Ergebnis dieser Untersuchung ist nachstehend genauer dargelegt.

#### UEBER DIE EIGENSCHAFT UND DEN URSPRUNG DER ACIDITÄT DES MINERALBODENS.

Es gibt in verschiedenen Gegenden Japans Böden, die wenig Humus enthalten und doch eine starke rote Reaktion auf Lakmus zeigen. Aber dieser saure Bestandteil ist nicht wasserlöslich; nur der Teil des blauen

Lackmuspapiers wird rot gefärbt, der feuchten Boden berührt. Ferner kann, wie schon in der Einleitung bemerkt, sofort eine saure Reaktion in der Lösung nachgewiesen werden, wenn eine neutrale Salzlösung, wie z. B. KCl,  $K_2SO_4$ ,  $KNO_3$ , NaCl etc. zugesetzt wird.

Wenn manche von unseren stark sauren Böden mit Natriumcarbonatlösung gekocht werden, färbt sich das Filtrat nur etwas gelb und zeigt so Anwesenheit einer Spur von Humus. Die Acidität dieses Bodens wird sogar nach einer einstündigen Erhitzung auf  $250^\circ C$  nicht vernichtet. Sie verringert sich aber, wenn diese Böden einige Stunden der Weissglut ausgesetzt werden.

Sowohl der wässrige wie der alkalische Extrakt des Bodens zeigt nur eine sehr schwache Spur von  $SO_3$  und Cl; deshalb kann man die Acidität nicht auf basisches Chlorid oder Sulphat des Aluminiums oder Eisens zurückführen.

Wenn diese sauren Böden mit Ammoniak oder Alkalilauge behandelt und nach dem Filtrieren und der Auswaschung bei  $100^\circ C$  getrocknet werden, haben sie nicht mehr die Eigenschaft, blaues Lackmuspapier zu röten und ergeben auch mit neutralen Salzlösungen keine sauerreagierende Lösung mehr.

Die auf den ersten Blick auffallende Erscheinung, dass die Produktion an organischen Stoffen bei Getreide, Reis, Rettich u.a. in unseren sauren Böden, die mit  $(NH_4)_2SO_4$  oder  $K_2SO_4$  gedüngt worden, noch kleiner ist als die Produktion auf den ungedüngten Böden, stimmt genau mit unserer Beobachtung überein, dass nach Anwendung neutraler Düngesalze die Bodenlösung stark sauer wird.

*Cornu* hat in *Tschermaks Min. u. Petrog. Mitteilungen* von 1905 u. 1906 über die Reaktion der Mineralien geschrieben, und Mineralogen wie *Kergott*, *Rogers* und *Hoffmann* haben eine alkalische Reaktion verschiedener Silikate beobachtet. *Hoffmann* kommt zu dem Schluss, dass alle basischen und normalen Silikate die Monoxyd enthalten, eine alkalische Reaktion auf Lackmus zeigen, mit Ausnahme solcher, die hauptsächlich Magnesia enthalten. Solche Salze aber, die in Bezug auf  $SiO_2: RO$ , das Verhältnis von 3:1 übertroffen haben, zeigen keine alkalische Reaktion auf Lackmus.

*Cornu* hat die Reaktion auf Lackmus von 150 Mineralien untersucht und beobachtet, dass ein wasserhaltiges Silikat mit Namen Hibscht ( $H_4CaAl_2Si_2O_{10}$ ) eine entschieden saure Reaktion zeigt, nach dem Glühen aber eine alkalische. Die saure Reaktion des Minerals ist nach Behandlung mit conc. Essigsäure und Auswaschung verstärkt.

Er hat weiter gefunden, dass einige Mineralien der Kaolingruppe z. B. Pyrophyllit, Halloisit, Allophan, Rectorit und Pholerit, und einige Sorten von Glimmergruppen, Eisen- und Aluminiumphosphate, Hydroxyde und Opalgruppen saure Reaktion auf Lackmus zeigen.

In *Hintzes* Mineralogie finden wir die folgenden sauren Zeolithe verzeichnet.

Hydronephilit,	$HNa_2Al_3Si_3O_{12} + 3 H_2O.$
Laumontit	$H_4CaAl_2Si_4O_{14} + 2 H_2O.$
Faujasit	$H_4Na_2CaAl_4Si_{10}O_{33} + 18 H_2O$
Apophyllit	$H_2(Ca, K_2)Si_2O_6 + H_2O$
Epistilbit	$H_4CaAl_2Si_6O_{18} + 3 H_2O.$

*Tschermak*<sup>1)</sup> erklärt, dass diese Mineralien als saure Salze betrachtet werden müssen, in denen nur ein Teil des Wasserstoffes von der Polykieselsäure von Ca, Al oder Na ersetzt ist. Aber wir fanden keine Antwort auf die Frage, ob diese Zeolithe Lackmuspapier röten würden, obgleich man es nach der Analogie erwarten sollte.

Bei genauer Untersuchung von fein gepulvertem Heulandit aus *Island* und *Tyrol*, von Faujasit aus *Baden* und *Böhmen*, hat der Verfasser keine Spur von saurer Reaktion auf Lackmus beobachtet, obgleich ihren Formeln nach, wie oben bemerkt, diese Mineralien Hydroxylgruppen enthalten. Sieben Proben der Zeolithe aus verschiedenen Gegenden sind mit verdünnter Essigsäure behandelt und nach der vorsichtigen Auswaschung ist der Rest vor und nach der Behandlung mit einer neutralen  $K_2SO_4$ -Lösung auf die Reaktion auf Lackmus geprüft worden; folgende Tabelle zeigt das Resultat:

1) *Hintze*: Handbuch f. Mineralogie. II. S. 1655.

## Reaktion der Zeolithe.

Zeolithe <sup>1)</sup>	Reaktion von		
	Orig. Mineralien	Nach der Behandlung mit Essigsäure	Extrakt desselben Restes mit K <sub>2</sub> SO <sub>4</sub> Lösung.
Heulandit ( <i>Thyrol</i> ) ... ..	neutral	sauer	sauer
Heulandit ( <i>Island</i> ) ... ..	do.	do.	stark sauer
Faujasit ( <i>Böhmen</i> ) ... ..	do.	do.	stark sauer
Mesolit ( <i>Böhmen</i> ) ... ..	do.	do.	stark sauer
Chabasit ( <i>Oberstein</i> ) ... ..	do.	do.	stark sauer
Natrolit ( <i>Böhmen</i> ) ... ..	do.	schwach sauer	schwach sauer
Phyllipsit ( <i>Havana</i> ) ... ..	do.	stark sauer	stark sauer

Weiter fand ich, dass unter zwanzig Sorten Kaolin aus verschiedenen Gegenden dreizehn (65%) saure, vier neutrale und drei alkalische Reaktion auf Lackmus gezeigt haben. Diese sauer reagierenden Kaoline verhalten sich gegen neutrale Salzlösungen ganz ebenso wie unsere sauren Böden, und neutral oder alkalisch reagierende Kaoline zeigen nach der Behandlung mit verdünnten Säuren auch saure Reaktion auf Lackmus und haben dieselbe Eigenschaft gegen neutrale Salzlösungen wie unsere sauren Böden.

Einige fein pulverisierte Gesteine und gesteinsbildende Mineralien, namentlich Granit, Gneis, Hornblende-Andesit, Basalt, Glimmer und Feldspat zeigen eine *alkalische* Reaktion auf Lackmus, aber ich habe beobachtet, dass diese Gesteine und Mineralien nach einer mehrwöchent-

1) Der Verfasser möchte Herrn Prof. Dr. B. Kitoh von der naturwissenschaftlichen Fakultät der Kaiserlichen Universität in *Tokio* herzlichen Dank sagen dafür, dass er die Freundlichkeit hatte ihn mit diesen Proben zu versehen und die Literatur einsehen zu lassen. Die Formeln dieser Zeolithe entsprechen nach Hintzes Mineralogie:

Heulandit: siehe umstehend.

Faujasit       "       "

Mesorit:     Na<sub>2</sub>CaAl<sub>4</sub>Si<sub>6</sub>O<sub>20</sub>·4H<sub>2</sub>O+H<sub>2</sub>O

Chabasit,   (Ca, Na<sub>2</sub>)Al<sub>2</sub>Si<sub>4</sub>O<sub>12</sub>+6H<sub>2</sub>O

Phyllipsit: CaAl<sub>2</sub>Si<sub>5</sub>O<sub>14</sub>+5H<sub>2</sub>O.

Die entsprechenden Basen im essigsauren Auszug sind immer nachgewiesen worden.

lichen Behandlung mit wässriger Kohlensäure sauer reagieren und sich auch ganz ähnlich verhalten, wie jene saueren Mineral-Böden.

10 g fein pulverisierte Proben jener Gesteine und Mineralien wurden in Erlenmeyer-Kolben mit Wasser angesetzt, jeden Tag  $\text{CO}_2$ -Gas durchgeleitet und das Wasser einmal wöchentlich erneuert. Nach einer derartigen hunderttägigen Behandlung wurden die Pulver mit Wasser vollständig ausgewaschen; die Reaktion derselben sowie der Extrakte mit neutraler Kalisalzlösung wird aus folgender Tabelle ersichtlich:

Gesteine u. Mineralien	Reaktion der Original-Proben	Reaktion nach der Behandlung mit wässrigem $\text{CO}_2$	
		Mit Wasser	Nach Zusatz v. KCl-Lös.
Granit	alkalisch	schw. sauer	schw. sauer
Gneis	alkalisch	do.	sauer
Hornblende-Andesit	schw.-alkalisch	do.	sauer
Basalt	stark-alkalisch	do.	schw. sauer
Feldspat	do.	do.	do.
Glimmer	do.	sauer	sauer

Es waren also wieder Silikate, die sich ganz ähnlich wie unsere sauren Böden verhalten, welche aus gewöhnlichen Gesteinen und Mineralien gebildet werden. Da das Kaolin bei der Einwirkung von  $\text{CO}_2$  auf Feldspat entsteht, war der Verfasser zuerst der Meinung, dass die Acidität saurer Mineralböden wahrscheinlich auf den Kaolinit oder verwandte saure Silikate<sup>1)</sup> zurückzuführen sei. Das war aber nicht richtig wie meine spätere Untersuchung erwiesen hat.

Bei dem Extrakt, den man bei wiederholter Behandlung von fein pulverisierten Gesteinen und Mineralien mit wässriger Kohlensäure erhält, lieferte die Analyse folgende Werte:

1) Ausser dem eigentlichen Kaolinit gibt es viele verwandte Mineralien, z. B. Halloysit, holerit, Rektorit, Newtonit, Allophan, Indianit, Pyrophyllit, Montmorillonit etc.



Die Bestandteile aufgelöst mit wässriger Kohlensäure  
während zwölf Wochen:

Bestandteile aufgelöst	Granit		Gneis		Hornblende- Andesit		Basalt		Feldspat	
	%	Ratio	%	Ratio	%	Ratio	%	Ratio	%	Ratio
SiO <sub>2</sub>	0,022	1,0	0,017	0,7	0,031	1,7	0,056	1,7	0,031	1,4
Al <sub>2</sub> O <sub>3</sub>	0,048	2,1	0,050	2,1	0,106	5,9	0,052	1,5	0,036	1,7
Fe <sub>2</sub> O <sub>3</sub>	0,558	24,2	0,635	26,6	0,152	8,5	0,833	25,1	0,402	18,5
CaO	0,417	18,1	0,418	17,5	0,350	19,6	0,679	20,4	0,461	21,3
MgO	0,409	17,7	0,389	16,3	0,373	20,8	0,498	15,0	0,337	15,6
K <sub>2</sub> O	0,070	3,0	0,084	3,5	0,070	3,9	0,071	2,1	0,082	3,8
Na <sub>2</sub> O	0,782	33,9	0,792	33,3	0,709	39,6	1,134	34,1	0,816	37,7
P <sub>2</sub> O <sub>5</sub>	Spur	—	Spur	—	Spur	—	Spur	—	Spur	—
Summe	2,306	100	2,385	100	1,791	100	3,323	100	2,165	100

Aus diesen Zahlen hat der Verfasser nachstehend berechnet, um wie gross das prozentuale Verhältnis der aufgelösten Bestandteile zu der in Originalproben enthaltenden ganzen Menge<sup>1)</sup> der resp. Bestandteile ist:

1) Die Zusammensetzung dieser Gesteine und Mineralien war folgende:

Bestandteile	Granit	Gneis	Hornblende- Andesit	Basalt	Feldspat	Glimmer
SiO <sub>2</sub>	68.74	65.60	65.01	48.37	59.12	31.61
Al <sub>2</sub> O <sub>3</sub>	16.90	15.40	17.10	9.50	20.75	14.90
Fe <sub>2</sub> O <sub>3</sub>	1.50	5.10	5.50	17.80	0.80	6.00
CaO	1.90	2.60	3.85	9.28	1.05	3.66
MgO	0.62	1.96	0.83	4.29	0.80	29.03
K <sub>2</sub> O	7.82	5.69	3.41	3.48	10.45	8.62
Na <sub>2</sub> O	4.61	4.33	5.12	7.18	6.26	5.52
P <sub>2</sub> O <sub>5</sub>	Spur	Spur	Spur	Spur	0.77	0.64

Prozentsatz der aufgelösten Bestandteile zu der ganzen Menge in Originalproben.<sup>1)</sup>

Bestandteile	Granit	Gneis	Hornblende- Andesit	Basalt	Feldspat
PiO <sub>2</sub>	0,032%	0,025%	0,047%	0,115%	0,052%
Al <sub>2</sub> O <sub>3</sub>	0,284 „	0,324 „	0,619 „	0,547 „	0,173 „
Fe <sub>2</sub> O <sub>3</sub>	37,200 „	12,450 „	2,763 „	4,679 „	50,250 „
CaO	21,147 „	16,076 „	9,090 „	7,316 „	39,733 „
MgO	65,967 „	19,846 „	44,939 „	18,601 „	42,125 „
K <sub>2</sub> O	0,892 „	1,476 „	2,052 „	2,040 „	0,784 „
Na <sub>2</sub> O	16,963 „	18,290 „	13,847 „	15,793 „	13,035 „
P <sub>2</sub> O <sub>5</sub>	Spur	Spur	Spur	Spur	Spur

Es ist merkwürdig, dass eine so grosse Menge von MgO, CaO, Fe<sub>2</sub>O<sub>3</sub> und Na<sub>2</sub>O durch CO<sub>2</sub>-Wasser aufgelöst worden ist, während sehr wenig P<sub>2</sub>O<sub>5</sub>, SiO<sub>2</sub>, und K<sub>2</sub>O in die Lösung gekommen ist.

1) *Richard Müller* fand, dass folgende Menge von Bestandteilen etlicher Mineralien durch CO<sub>2</sub>-Wasser während sieben Wochen aufgelöst worden ist (*Tschermaks Min. u. Petrog. Mitteilung. 1877, S. 25*).

Prozentsatz der aufgelösten Bestandteile zu ihrer ganzen Menge in Originalproben.

Bestandteile	Adular	Oligoklas	Hornblende	Magnetit	Apatit	Olivin	Serpentin
SiO <sub>2</sub>	0.1552	0.2370	0.4190	Spur	—	0.873	0.354
Al <sub>2</sub> O <sub>3</sub>	0.1368	0.1713	Spur	—	—	Spur	—
Na <sub>2</sub> O	—	2.367	Spur	—	—	—	—
CaO	—	3.213	8.528	—	2.168	Spur	—
MgO	—	—	—	—	—	1.291	2.649
P <sub>2</sub> O <sub>5</sub>	—	—	—	—	1.822	—	—
FeO	Spur	Spur	4.829	0.942	—	8.733	1.527
Total	0.328	0.533	1.530	0.307	2.018	2.111	1.211

Die Acidität des Bodens<sup>1)</sup> kann bei der Behandlung mit verdünnten Säuren zunehmen. Zwei granitische schwach saure Sandböden aus *Sumiyoshi* bei *Kobe*, und ein alluvialer schwach saurer Sandlehm Boden aus *Yamaguchi* waren mit verdünnter Essigsäure verschiedenartig behandelt worden, genau ausgewaschen und getrocknet. Die Acidität des Bodens wurde folgendermassen bestimmt: zu jedem 100 g Boden wurden 250 ccm 1/1 Normallösung von KCl zugesetzt, dreimal täglich umgeschüttelt, nach fünf Tagen filtriert, 125 ccm abgegossen, mit 1/10 n NaOH-Lösung titriert, mit Phenolphthalein als Indikator. Das Resultat ist aus der folgenden Tabelle ersichtlich. Die Acidität entspricht der von 50 g Boden, ausgedrückt in ccm 1/10 n NaOH-Lösung.

Behandlungsart des Bodens	Acidität des Bodens <sup>2)</sup> in ccm 1/10 n NaOH		
	<i>Sumiyoshi</i> -Boden (a)	<i>Sumiyoshi</i> -Boden (b)	<i>Yamaguchi</i> -Boden
1. Original Boden ... ..	1.42	0.10	0.10
2. Befruchtet mit 1% Essigsäure u. gleich ausgewaschen ... ..	3.16	0.30	1.20
3. do. mit 5% Essigsäure	—	1.45	3.80
4. do. mit 10% Essigsäure	5.25	2.55	6.25
5. Behandlung mit 10% Essigs. auf 5 Minuten	10.41	4.90	7.65
6. do. 30 Minuten ... ..	12.16	5.30	8.45
7. do. 1 Stunde ... ..	11.91	5.35	9.00
8. do. 4 Stunden ... ..	14.08	6.15	10.05
9. do. 24 Stunden ... ..	16.49	7.15	11.35

1) Neulich hat *Osugi* in *Morioka, Japan*, über die Aciditätssteigerung des sauren Bodens durch HCl bei verschiedenen Konzentrationen Untersuchungen angestellt, über deren Resultate wie folgt berichtet wird:

Acidität des Bodens in ccm 1/10 n NaOH.

	I.	II.	III.
Original Boden ... ..	4.9	3.4	3.6
Durch 1% HCl (kalt) ... ..	6.6	8.7	10.6
„ 5% HCl (kalt) ... ..	11.1	13.0	9.2
„ „ „ (heiss) ... ..	12.0	12.3	8.6
„ 10% „ „ ... ..	6.9	6.4	4.1
Conc. HCl. „ „ ... ..	3.8	3.3	1.8

Bemerkung: je 20 g lufttrockenen Bodens wurden nach der Einwirkung von HCl-Lösungen (die Menge der Lösung?) ausgewaschen, getrocknet, darauf mit 50 ccm 1/1 normaler KCl-Lösung behandelt, und nach 5 Tagen die überstehende Flüssigkeit mit 1/10 n NaOH titriert; die Aciditätswerte beziehen sich auf die ganze Menge der überstehenden Flüssigkeit.

2) Die Resultate sind Durchschnittszahlen von zwei parallelen Bestimmungen.

Ein Alluviumlehm Boden von dem Felde der *Kagawa*-Bezirks-Versuchsstation und ein anderer Alluviumsandlehm Boden von dem Felde der *Hiogo*-Bezirks-Versuchsstation wurden mit einigen verdünnten organischen und

Säuren	Acidität des Bodens <sup>1)</sup> in ccm $\frac{1}{10}$ n NaOH Lösung					
	<i>Kagawa</i> -Boden			<i>Hiogo</i> -Boden		
	A.	B.	Durchschnitt	A.	B.	Durchschnitt
(Original-Boden)	neutral	neutral	neutral *	0.10	0.10	0.10
2% Ameisensäure ... ..	20.30	19.70	20.00	12.10	11.80	11.95
2% Essigsäure ... ..	12.80	12.60	12.70	3.20	4.00	3.60
2% Oxalsäure ... ..	2.00	1.70	1.85	0.50	0.50	0.50
2% Salzsäure ... ..	19.60	19.70	19.65	13.80	13.80	13.65
2% Schwefelsäure ... ..	19.60	19.60	19.60	12.70	12.80	12.75

1) Die Extrakte dieser Böden wurden mit verschiedenen Säuren mit folgendem Resultat analysiert:

1. *Kagawa*-Boden

Prozentsatz der ganzen Menge (löslich in conc. heißen HCl.)  
von einzelnen Bestandteile.

Bestandteile aufgelöst	Ameisensäure	Essigsäure	Oxalsäure	Salzsäure	Schwefelsäure
SiO <sub>2</sub>	26.52	7.61	<b>75.42</b>	45.09	56.82
Al <sub>2</sub> O <sub>3</sub>	3.16	0.17	<b>21.22</b>	13.27	11.43
Fe <sub>2</sub> O <sub>3</sub>	3.28	0.27	<b>52.26</b>	32.90	32.26
Mn <sub>3</sub> O <sub>4</sub>	7.58	5.65	32.30	21.56	26.17
CaO	45.26	31.09	16.83	58.55	72.91
MgO	7.02	5.17	24.07	17.07	21.90
K <sub>2</sub> O	3.35	2.21	12.69	7.66	7.17
Na <sub>2</sub> O	10.45	8.33	14.94	11.59	12.98
P <sub>2</sub> O <sub>5</sub>	4.81	2.86	<b>62.86</b>	51.28	51.28
SO <sub>3</sub>	15.18	15.76	27.32	24.82	—

anorganischen Säuren drei Tage lang behandelt (200 g Boden: 1000 ccm Lösung), filtriert, ausgewaschen, getrocknet und durch KCl-Lösung ihre Acidität bestimmt mit folgendem Resultat: (S.o.)

Es ist merkwürdig, dass die Oxalsäure am schwächsten auf die Aciditätssteigerung des Bodens wirkt, zunächst dann die Essigsäure kommt und dass die Ameisensäure am stärksten ist, während beide Mineralsäuren ungefähr gleich stark wie Ameisensäure sind.

### 2. Hiogo-Boden.

Prozentsatz der ganzen Menge (löslich in conc. heissen HCl) der einzelnen Bestandteile.

Bestandteile aufgelöst	Ameisensäure	Essigsäure	Oxalsäure	Salzsäure	Schwefelsäure
Si O <sub>2</sub>	16.16	5.10	<b>69.90</b>	50.97	62.62
Al <sub>2</sub> O <sub>3</sub>	1.81	0.22	<b>16.44</b>	6.67	8.44
Fe <sub>2</sub> O <sub>3</sub>	0.26	0.13	<b>36.58</b>	17.89	18.16
Mn <sub>3</sub> O <sub>4</sub>	17.62	10.69	34.97	39.97	43.55
Ca O	30.52	22.41	22.34	46.29	54.14
Mg O	8.20	6.51	22.39	20.54	23.07
K <sub>2</sub> O	10.28	6.38	18.87	22.62	19.50
Na <sub>2</sub> O	6.34	5.80	8.27	9.53	9.36
P <sub>2</sub> O <sub>5</sub>	6.00	3.93	<b>58.48</b>	40.00	40.69
S O <sub>3</sub>	6.94	9.80	18.98	14.69	—

Es ist sonderbar, dass eine grössere Menge von SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub> und P<sub>2</sub>O<sub>5</sub> sogar durch Oxalsäure sowie durch Salzsäure und Schwefelsäure aufgelöst wurde, trotzdem die Oxalsäure am schwächsten auf die Aciditätssteigerung des Bodens wirkt.

Die in conc. heissen HCl löslichen Bestandteile sind folgende:

### Prozentsatz von luft-trocken feiner Erde

Bestandteile.	Kāgarwa-Boden.	Hiogo-Boden.
SiO <sub>2</sub>	0.330	0.206
Al <sub>2</sub> O <sub>3</sub>	2.450	2.250
Fe <sub>2</sub> O <sub>3</sub>	1.550	1.900
Mn <sub>2</sub> O <sub>3</sub>	0.269	0.290
CaO	0.470	0.461
MgO	0.420	0.427
K <sub>2</sub> O	0.145	0.141
Na <sub>2</sub> O	0.245	0.295
P <sub>2</sub> O <sub>5</sub>	0.133	0.145
SO <sub>3</sub>	0.056	0.049

Wenn zu dem Filtrat des sauren Bodens nach Behandlung mit neutralen Salzlösungen Ammoniak oder Alkalilauge zugesetzt wird, erscheint ein flockiger, weisser Niederschlag, welcher nicht in Salmiaklösung löslich ist und hauptsächlich aus Aluminiumhydroxyd besteht.<sup>1)</sup> Das Filtrat des neutralen oder alkalischen Bodens, sowie der wässrige Extrakt des sauren Bodens aber ergeben keinen solchen Niederschlag.

Ich habe beobachtet, dass die Menge des Aluminiumhydroxyds in der Lösung, die man nach Behandlung mit neutraler Salzlösung bei dem sauren Boden erhält, nicht nur mit der Acidität des Bodens im Verhältnis steht, sondern auch mit der bei Titration verbrauchten Menge der normalen Alkalilösung gut übereinstimmt, wie folgende Tabelle zeigt:

Boden	Neutrale Salzlösung gebraucht	ccm v. 1/10 n Alkalilösung befördert	Al <sub>2</sub> O <sub>3</sub> (g)		Abweichung
			Berechnet	Gefunden	
Niigata A.	KCl	80.05	0.1496	0.1412	(-) 0.0084
Nara A.	K <sub>2</sub> SO <sub>4</sub>	18.20	0.0310	0.0312	(+) 0.0002
do. B.	do.	16.40	0.0279	0.0275	(-) 0.0004
do. C.	do.	16.30	0.0278	0.0316	(+) 0.0038
do. D.	do.	6.40	0.0109	0.0128	(+) 0.0019
Niigata C.	do.	11.60	0.0197	0.0220	(+) 0.0023
Nara A.	KNO <sub>3</sub>	17.72	0.0302	0.0311	(+) 0.0009
do. E.	do.	20.20	0.0344	0.0355	(+) 0.0011
Niigata D.	do.	10.55	0.0179	0.0181	(+) 0.0002
Nara A.	KClO <sub>4</sub>	16.50	0.0281	0.0286	(+) 0.0005
do. B.	do.	15.15	0.0258	0.0270	(+) 0.0018

Wir ersehen aus der obigen Tabelle, dass zwischen den berechneten und gefundenen Zahlen für Aluminiumhydroxyd gute Übereinstimmung herrscht, deshalb folgert der Verfasser, dass ein Teil des Aluminiumhydroxyds im sauren Boden ziemlich locker gebunden ist, weil es schon

1 Einige besondere Böden enthalten im wässrigen Extrakt Aluminiumsulfat, oder Aluminiumchlorid, einige Quellen enthalten auch dieselben Verbindungen.

durch neutrale Salzlösung leicht in Lösung gebracht wird, und dass die saure Reaktion, welche durch Zusatz von neutraler Salzlösung zu unserem sauren Boden erzeugt wird, auf der Bildung eines sauren Aluminiumsalzes<sup>1)</sup> beruht.

Manchmal aber kommt nicht nur Aluminium sondern auch Eisen in dem Filtrat vor, und folgende Berechnung zeigt, dass in diesen Fällen die gefundenen Zahlen des Aluminiums und Eisens zusammen mit den berechneten Zahlen übereinstimmen.

		<i>Niigata</i> -Boden	<i>Nara</i> -Boden.
Al <sub>2</sub> O <sub>3</sub>	} im Filtrat ... ..	0,0183 g.	0,0824 g.
Fe <sub>2</sub> O <sub>3</sub>		0,0223 „	0,0216 „
Berechnete Menge der 1/10 n NaOH Lösung entsp.	{	Al <sub>2</sub> O <sub>3</sub> 10,85 ccm	48,34 ccm
		Fe <sub>2</sub> O <sub>3</sub> 8,33 „	8,09 „
Summe... ..		19,18 „	56,43 „
Gefundene Menge der 1/10 n NaOH Lösung... ..		19,70 „	59,20 „
Abweichung... ..		(-) 0,52 „	(-) 2,77 „

Aus den Ergebnissen der vorhergehenden Versuche könnte man schliessen, dass die Acidität des Mineralbodens auf Kaolin oder verwandte saure Silikate zurückzuführen sei.<sup>2)</sup> Wäre dies der Fall, dann würden Kaoline sehr stark sauer reagieren und viel Tonerde durch neutrale Salzlösung in Lösung gedrängt werden. Kaoline reagieren aber nicht immer sauer, manchmal neutral, manchmal auch alkalisch. Der am stärksten sauer reagierende Kaolin<sup>3)</sup>, welchen ich untersucht habe, gab mir einen kleinen Teil Tonerde auf Zusatz von KCl in die Lösung ab, nämlich 194 mg pro 100 g Boden. Unter 1300 Bodenproben konnte ich

1) *Veitch* hat eine etwas ähnliche Meinung in Bezug auf die *Hopkinsche* Natriumchloridmethode geäußert, aber er meint, dass je neutrale Salzlösung auf *neutrale Silikate* im Boden wirke und dass das dabei entstehende Aluminiumchlorid sauer reagiere. (Näheres unten.) *Journal Amer. Chem. Soc.* 1904, 637.

2) Über diese Frage beabsichtige ich weitere Versuche zu machen.

3) Der Kaolin aus *Yoshino*, *Nara*-Bezirk, stammt aus der *Chichibu*-Paläozoischen Formation.

in dem am stärksten sauer reagierenden Tonboden<sup>1)</sup> durch KCl sogar nur 0,974 g pro 100 g Tonerde in die Lösung überführen.

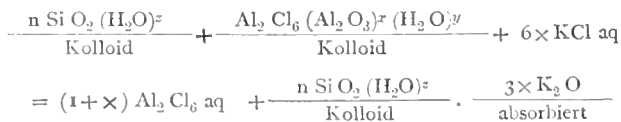
Der Verfasser fand, als er in dem anorganisch-chemischen Institut zu Göttingen arbeitete, dass verschiedene kolloidale Substanzen Tonerde und Eisen absorbieren<sup>2)</sup> und dieselben bei Einwirkung von KCl wieder in die Lösung abgeben.

Kieselsäuregel<sup>3)</sup>, aus Wasserglas hergestellt und an der Luft getrocknet, reagiert ziemlich stark sauer auf Lakmus, während dessen Wasserauszug ganz schwach sauer reagiert.

Humussäure (aus Torf), Kaolin und verschiedene Böden wurden mit 1/1 normaler Aluminiumchlorid- resp. Eisenchloridlösung geschüttelt und gut ausgewaschen, die lufttrockenen Substanzen mit 1/1 normaler KCl-Lösung (bei Humussäure 4 g auf 100 ccm, bei Kaolin und den Böden 40 g auf 100 ccm) behandelt und nach Erreichung des Gleichgewichtszustandes die Hälfte der überstehenden Flüssigkeit herausgenommen und mit 1/10 normaler KOH-Lösung titriert mit folgendem Ergebnis:

1) Der Tonboden aus *Tokigwa*, *Gifu*-Bezirk, stammt aus der tertiären Formation.

2) Früher hat *Van Bemmelen* beobachtet, dass in der mit heisser starker Salzsäure ausgezogenen und mit KCl-Lösung behandelten Erde geringe Mengen von Aluminium durch Kalium ersetzt wurden. Er führt ferner aus: "Trotz längeren Auswaschens der mit Salzsäure ausgezogenen Erde bleibt eine geringe Menge Aluminiumchlorür als basisches Salz zurück. Dieses basische Salz, durch die Anziehung der gelatinösen Kieselsäure unterstützt (wenn ich mich so ausdrücken darf) setzt sich mit KCl um wie folgt:



*Van Bemmelen*: Die Absorption, S. 133, und *Ldw. Vers. St. Bd.* 21. 161 u. 162 (1878).

3) Je 10 g desselben Kieselsäuregels (57% Trockensubstanz) wurde mit je 100 ccm Wasser resp. 1/1 normaler KCl-Lösung geschüttelt und je 50 ccm der überstehenden klaren Flüssigkeit mit normaler KOH-Lösung titriert; zur Neutralisation waren erforderlich 0,4 resp. 0,35 ccm 1/20 n KOH, während dieselbe, mit AlCl<sub>3</sub>-Lösung behandelte und gewaschene Kieselsäure nach Zusatz von 1/1 normaler KCl-Lösung 0,35 ccm 1/20 n KOH erforderte. In der Tat reagiert das Kieselsäuregel, welches mit AlCl<sub>3</sub>- oder FeCl<sub>3</sub>-Lösung behandelt und ausgewaschen wurde, stärker sauer, und nach Zusatz von neutraler Salzlösung liess sich Tonerde bezw. Eisen in der Lösung nachweisen.



Substanzen	Acidität <sup>1)</sup> in ccm 1/10 n Alkali (pro 100 g Substanz.)		
	Original-Substanz	mit AlCl <sub>3</sub> be- handelt	mit FeCl <sub>3</sub> be- handelt
<i>Yehime</i> -Boden ... ..	(neutral)	32	—
<i>Hiogo</i> -Boden ... ..	„	17	12.5
<i>Nagano</i> -Boden ... ..	„	56.5	—
<i>Nishigahara</i> -Boden ... ..	„	0.75	—
<i>Ikoma</i> -Boden ... ..	9	20	17
<i>Yoshino</i> -Boden ... ..	26	30.5	26
<i>Gifu</i> -Boden ... ..	70	72	—
<i>Hiroshima</i> -Boden ... ..	26.5	28	—
<i>Niigata</i> -Boden ... ..	12	23.5	—
<i>Kobushi</i> -Kaolin ... ..	2.5	50	—
<i>Gifu</i> -Kaolin ... ..	13.5	18	—
<i>Gainome</i> -Kaolin ... ..	(neutral)	36	41
<i>Yoshino</i> -Kaolin ... ..	38	49.5	—
<i>Korea</i> -Kaolin ... ..	0.75	52	50
Humussäure <sup>2)</sup> ... ..	—	160	47.5

Die obigen Ergebnisse zeigen, dass die neutralen Böden und das Kaolin durch Behandlung mit AlCl<sub>3</sub>- oder FeCl<sub>3</sub>-Lösung mehr oder weniger sauer wurden; die Acidität verstärkt sich bei bereits sauren Böden und sauren Kaolinen wie bei den Humussäuren. Die Acidität des

1) Diese Acidität entspricht der gefunden Menge KOH, welche nötig ist, um die Hälfte des Filtrats zu neutralisieren.

2) In der überstehenden Flüssigkeit von Humussäure, welche letztere mit destilliertem Wasser gewaschen wurde, lässt sich nach Behandlung mit 1/t normaler KCl-Lösung Tonerde und Eisen nachweisen.

Dieselbe Beobachtung wurde von *van Bemmelen*, nach Behandlung eines nicht klaren Wasserauszeuges der tonhaltigen Ackererde mit NH<sub>4</sub>Cl, gemacht. Der Auszug reagierte schwach sauer und enthielt eine nachweisbare Menge Eisen. *Van Bemmelen* war der Ansicht, dass die Humussubstanzen in der Ackererde eine geringe Menge NH<sub>4</sub>Cl zersetzt, und die freigewordene Salzsäure danach eine Spur Eisenoxyd gelöst hätte. Nach des Verfassers Meinung aber ist es mehr wahrscheinlich zu folgern, dass die durch Humussäure resp. kolloiden Ton absorbierten Tonerde- und Eisenverbindungen durch KCl (in *van Bemmelen's* Fall: NH<sub>4</sub>Cl) in die Lösung überführt wurden. (Basenaustausch).

Bodens u.a. Substanzen wurde im allgemeinen durch Aluminiumchlorid mehr gesteigert als durch Eisenchlorid.

Der Verfasser hat ferner festgestellt, wieviel Tonerde resp. Eisen von Böden u.a. Substanzen absorbiert und wieviel von dieser Menge durch KCl wieder in die Lösung gedrängt wurde. Die Resultate dieser Untersuchung gibt die folgende Tabelle :

Substanzen	Menge der Tonerde (mg pro 50 g sub.)		Menge des Eisens (mg pro 50 g sub.)	
	aufgenommen	durch KCl verdrängt	aufgenommen	durch KCl verdrängt
Humussäure ... ..	415	408	2,625	189.6
Gainome-Kaolin ... ..	94.5	91.8	250	163.8
Korea-Kaolin ... ..	—	—	280	163.9
Yoshino-Boden ... ..	30.4	11.5	155	0
Ikoma-Boden ... ..	31.5	23.4	127.5	26.6
Hiogo-Boden ... ..	272.9	43.4	187.5	46.6

Aus obiger Tabelle ersehen wir, dass die durch Kaoline, Böden und Humussäure aufgenommene Tonerde in grösserer Menge wieder in die Lösung übergeht als das Eisen. Besonders viel Eisen wurde durch Humussäure<sup>1)</sup> aufgenommen.

Weiterhin habe ich die Beobachtung gemacht, dass das durch Kaoline, Humussäure oder Böden absorbierte Eisen durch Tonerde ersetzt wird, nicht aber umgekehrt Tonerde durch Eisen. Wie ich schon oben erwähnt habe, lässt sich bei den meisten sauren Mineralböden in den mit neutraler Salzlösung gemachten Auszügen Tonerde nachweisen, dagegen findet man Eisen selten in dem Auszug vor. Es ist mir jetzt klar geworden, warum in sauren Mineralböden die Tonerde eine grössere Rolle spielt als das Eisen.

Der „Permutit“, der nach dem Verfahren von R. Gans hergestellt wird, besitzt Bedeutung für die Technik (Wasserrreinigung), und nach den

1) Über die Einwirkung des kolloidalen Eisenoxyhydrates auf Moortorf siehe die *Bauman u. Guérysche* Arbeit: *Romanns* Bodenkunde III. Aufl. S. 50; und *B. Arino*: Intern. Mittlg. f. Bodenkunde, Bd. III, Heft 2/3 S. 131.

Untersuchungen von Gans<sup>1)</sup> hat der Permutit eine ausserordentlich grosse Austauschfähigkeit und ähnelt in seiner Zusammensetzung den Silikaten<sup>2)</sup>, die den Austausch in der Ackererde vermitteln. Neulich hat Georg Wiegner<sup>3)</sup> sehr interessante Untersuchungen über den Basenaustausch in der Ackererde ausgeführt. Zu diesen Untersuchungen bediente er sich des fabrikmässig hergestellten „Permutits“ nach dem Verfahren von R. Gans.

Nach meiner Untersuchung zeigt der „Permutit“ nach der Behandlung mit  $\text{AlCl}_3$ - resp.  $\text{FeCl}_3$ -Lösung keine saure Reaktion auf Lakmus, und das dadurch aufgenommene Aluminium<sup>4)</sup> resp. Eisen lässt sich durch die Base in der Neutralsalzlösung nicht ersetzen.

Wir haben aus den vorhergehenden Untersuchungen ersehen, dass die Gesteine und Mineralien, die mit wässriger Kohlensäure, sowie neutrale oder alkalische Kaoline und Böden, die mit Säuren behandelt wurden, eine mehr oder weniger saure Reaktion zeigen und sich gegen neutrale Salzlösungen ganz genau so verhalten wie unsere sauren Mineralböden. Es ist mit grosser Wahrscheinlichkeit anzunehmen, dass die durch Behandlung mit Säure entstandenen Tonerde- oder Eisenverbindungen durch kolloidale Substanzen absorbiert und deren positive Ionen durch die Base der neutralen Salzlösung ersetzt werden.

Da die Humussäuren ebenso wie andere mineralische kolloidale Substanzen in der Ackererde Tonerde- und Eisen-Salze absorbieren und dieselben durch neutrale Salzlösungen wiederum in Lösung zu bringen gestatten, so dürfte wohl die durch Kolloide absorbierte Tonerde und das Eisen nicht nur für die Acidität der Mineralböden sondern auch für diejenige der humussäuren Böden eine ausschlagende Rolle spielen.

Ramanns Behauptung, dass die bisher als „saure Böden“ bezeichneten „absorptiv ungesättigte Böden“ genannt werden sollten, ist nach meiner Meinung nicht ganz richtig. Wie schon erwähnt, reagieren die mit  $\text{AlCl}_3$

1) Chem. Ind. 42, 197-200; Chem. Centl. Blatt, 1909, I, 2031.

2) In seiner chemischen Zusammensetzung steht der „Permutit“ dem natürlichen Mineral Chabasit am nächsten, aber er ist vollkommen amorph.

3) Journal f. Landw. 60. 1912, S. III.

4) 10 g „Permutit“ hat durch Einwirkung von 25 ccm 1/1 n  $\text{AlCl}_3$ -Lösung 181,5 mg  $\text{Al}_2\text{O}_3$  aufgenommen.

resp.  $\text{FeCl}_3$  gesättigten Böden immer noch sauer, und solche Böden kommen in der Natur häufig vor. Wenn aber die absorbierenden Basen auf Alkalien und Erdalkalien beschränkt würden, so würde Ramanns Behauptung richtig sein.

### DAS VERHALTEN ZWISCHEN DEN VERSCHIEDENEN SALZLÖSUNGEN UND DER BODENACIDITÄT.

Es existiert ein grosser Unterschied zwischen der Acidität des Bodens bei der Behandlung mit verschiedenen Salzlösungen und zwar ergeben die leichten absorbierbaren Salze auch stärker saure Filtrate, z. B. Kalium- und Ammoniumsalze rufen eine stärkere Acidität hervor als Natrium-, Magnesium- und Calciumsalze. Je 100 g von vier sauren Böden wurden in Kolben nach Zusatz von je 250 ccm Salzlösungen unter zeitweiligem Umschütteln fünf Tage stehen gelassen und je 125 ccm der überstehenden klaren Flüssigkeit dann titriert nach dem Kochen mit 1/10 n NaOH Lösung; als Indikator wurde Phenolphthalein gebraucht. Die folgende Tabelle zeigt die zur Titration verbrauchte Menge NaOH Lösung.

#### A. Titrationsergebnis mit verschiedenen Chloridlösungen.

Boden	KCl	$\text{NH}_4\text{Cl}$	NaCl	MgCl	CaCl
<i>Yoshino</i> -Boden. ...	32,1 ccm	31,7 ccm	16,6 ccm	10,0 ccm	10,4 ccm
Vergleichung ...	100	99	52	31	32
<i>Shiga</i> -Boden. ...	18,5 ccm	—	9,6 ccm	10,3 ccm	9,0 ccm
Vergleichung ...	100	—	52	55	48
<i>Gifu</i> -Boden. ...	8,2 ccm	—	3,8 ccm	4,1 ccm	4,3 ccm
Vergleichung ...	100	—	39	49	51
<i>Nara</i> -Boden. ...	7,7 ccm	—	4,6 ccm	3,7 ccm	3,7 ccm
Vergleichung ...	100	—	59	48	48
Durchschnittl.- Vergleichung ...	100	99	51	46	45

#### B. Titrationsergebnis mit verschiedenen Kalisalzen.

Boden	KCl	$\text{KNO}_3$	$\text{KClO}_3$	$\text{K}_2\text{SO}_4$	KJ
<i>Yoshino</i> -Boden. ...	33,4 ccm	35,6 ccm	30,3 ccm	32,7 ccm	29,0 ccm
Vergleichung ...	100	106	99	98	87

Boden	KCl	KNO <sub>3</sub>	KClO <sub>3</sub>	K <sub>2</sub> SO <sub>4</sub>	KJ
<i>Shiga</i> -Boden. ...	18,5 ccm	18,5 ccm	—	11,1 ccm	—
Vergleichung ...	100	100	—	60	—
<i>Niigata</i> -Boden ...	11,3 ccm	10,6 ccm	9,3 ccm	9,4 ccm	8,7 ccm
Vergleichung ...	100	93	82	83	77
<i>Gifu</i> -Boden. ...	8,2 ccm	7,4 ccm	—	7,6 ccm	—
Vergleichung ...	100	89	—	90	—
<i>Nara</i> -Boden. ...	8,3 ccm	7,9 ccm	7,2 ccm	5,8 ccm	5,4 ccm
Vergleichung ...	100	96	88	70	60
Durchschnittl.- Vergleichung ...	100	99	90	80	76

N.B. Die Filtrate von Ammoniumchlorid und Kaliumjodid sind infolge ihrer starken Färbung schwer zu titrieren, deshalb wurde ihre Acidität aus der Aluminiummenge in der Lösung berechnet.

Obige Resultate ergeben, dass die Aciditätsgrade der Filtrate von Ammoniumchlorid und Kaliumchlorid ungefähr gleich sind und diese Acidität weit stärker als bei den anderen Chloriden auftritt. Die Aciditätsgrade bei Natriumchlorid, Magnesiumchlorid und Calciumchlorid sind unter einander ungefähr gleich, doch betragen sie nur die Hälfte der mit Ammoniumchlorid und Kaliumchlorid erhaltenen.

Was verschiedene Kalisalze betrifft, so ist die Acidität mit Kaliumchlorid und Kaliumnitrat die gleiche, während Kaliumchlorat, Kaliumsulfat sowie Kaliumjodid eine schwächere Acidität liefern.

## DAS VERHÄLTNISS ZWISCHEN DER KONZENTRATION DER KCl-LÖSUNG UND DER BODENACIDITÄT.

Auf je 100 g Bodenmenge wurden 250 ccm KCl-Lösung von verschiedenen Konzentrationen gegossen, nach 5 Tagen (mit zeitweiligem Umschütteln) 125 ccm von der überstehenden klaren Flüssigkeit abgemessen, gekocht und mit 1/10 n NaOH Lösung titriert. Das Resultat findet sich in der folgenden Tabelle:

## Acidität des Bodens in ccm 1/10 n NaOH Lösung.

Konzentration der KCl Lösung.	<i>Niigata</i> -Boden	<i>Kumamoto</i> -Boden	<i>Shiga</i> -Boden
1/50 normal	0,47	1,45	1,70
1/30 „	0,90	2,50	3,25
1/20 „	1,50	3,80	5,30
1/10 „	3,57	7,72	9,80
1/5 „	5,55	11,75	14,68
1/2 „	9,17	18,85	17,93
1/1 „	10,92	20,95	18,45
2/1 „	11,55	21,72	18,40
3/1 „	11,90	21,67	—

Leider habe ich nicht die Endkonzentration der KCl-Lösung bestimmt, jedoch kann man wohl annehmen, dass die Anfangs- und Endkonzentration der KCl-Lösung ziemlich dieselbe blieb, ausgenommen allerdings bei den am stärksten verdünnten Lösungen. Wie man aus der folgenden Figur ersehen kann, sind die Kurven, welche die vorstehende Tabelle illustrieren sollen, sehr ähnlich den bekannten Absorptionskurven.

## (FIGUR I.)

Wenn die Vorgänge nach der Gleichung

$$\frac{x}{m} = a c^{\frac{1}{n}}$$

verlaufen würden, dann müssten die Kurven, welche den Logarithmen von  $\frac{x}{m}$  und  $c$  entsprechen, gerade Linien sein. Man bekommt in dieser Weise die folgenden Diagramme.

## (FIGUR II.)

Wir sehen, dass alle drei Diagramme bei schwächerer Konzentration gerade Linien zeigen. Bei stärkeren Konzentrationen (in der Nähe des

Sättigungspunktes) gehen die Kurven ziemlich rasch in einen zur Abscisse parallelen Verlauf über.

### DAS VERHALTEN DER BODENACIDITÄT BEIM ERHITZEN.

Drei verschiedene Böden<sup>1)</sup> und eine Sorte Kaolin wurden auf verschiedene Temperaturgrade 20 Stunden erhitzt und davon die Bodenacidität nach obigem Verfahren festgestellt; es ergab sich folgendes Resultat:

Temperatur- grade.	Verlust des Gewichtes d. Bodens bei Erhitzung. (g)				Acidität d. Bodens in ccm 1/10 n NaOH.			
	Kaolin.	Nara- Boden	Shiga- Boden	Yoshino- Boden	Kaolin.	Nara- Boden	Shiga- Boden	Yoshino- Boden
Original- Boden.	—	—	—	—	33,33	6,15	18,72	28,60
40°C.	1,9	1,2	3,5	1,4	32,03	5,58	16,83	28,03
60°C.	2,2	1,4	3,7	1,6	29,73	5,63	16,73	27,53
80°C.	2,5	1,6	4,9	2,5	28,23	6,15	17,22	27,93
100°C.	2,9	1,8	5,4	2,9	26,43	8,48	18,90	31,10
120°C.	2,9	2,1	5,6	3,2	27,17	9,27	18,37	34,03
150°C.	2,9	2,5	5,7	3,5	26,47	6,00	19,53	38,93
200°C.	3,3	2,7	6,6	4,3	24,03	5,15	17,48	42,77
1 stünd. Glut	8,3	5,7	12,5	9,8	3,20	2,20	6,70	4,00
5 „ „	8,5	5,9	12,7	9,9	2,85	1,65	5,95	3,50

Es ergibt sich hieraus, dass Kaolin allmählich beim Erhitzen an Acidität abnimmt, während die Böden durch Erhitzen auf 40-60°C ihre Acidität etwas erniedrigen und bei höheren Temperaturen wieder an Acidität zunehmen; aber die Acidität des *Nara*- und *Shiga*-Bodens nimmt bei 150°C. resp. 200°C. wieder ab. Bei Gluthitze verlieren alle drei Böden und Kaolin den grössten Teil ihrer Acidität.

1) Der *Nara*-Boden ist ein sandiger Granitboden, der *Shiga*-Boden ein toniger Diluviumboden, und der *Yoshino*-Boden ein toniger *Chichibu*-Paläozoischer Boden.

## DAS VERHÄLTNISS ZWISCHEN DER GRÖSSE VON BODEN- BILDENDEN PARTIKELN UND DER BODENACIDITÄT.

Ein saurer sandiger Granit-Boden aus *Sumiyoshi* bei *Kobe* wurde durch verschiedene Siebe gesiebt, mit destilliertem Wasser gut ausgewaschen und dann die Acidität dieser Bodenteile nach obenstehendem Verfahren mit KCl Lösung bestimmt mit folgendem Resultat :

Grösse der Partikeln (mm.)	Acidität (ccm 1/10 n NaOH Lösung.)
2,0–3,00	1,60
1,00–2,00	2,00
0,50–1,00	2,64
0,25–0,50	7,60
0,25	21,90
0,50	18,10
Originalboden	6,90

Dieses Resultat ergibt, dass die feinsten Partikeln die grösste Acidität besitzen, während die grösseren nur geringe aufweisen.

## NEUE METHODEN ÜBER DEN NACHWEIS DER BODENACIDITÄT.

Die *Lakmuspapiermethode* ist die verbreitetste und leichteste, und man kann auch durch dieselbe unterscheiden, ob die Acidität einem löslichen oder unlöslichen Körper angehört. Die *Schützesche*<sup>1)</sup> *Ammoniakmethode* ist auch praktisch, für freie Humussäure aber nicht einwandfrei. Die *Albertsche*<sup>2)</sup> *Lithiumphosphatmethode* wird nicht bevorzugt, weil das

1) Viele Autoren bemerkten schon, dass Ammoniak nicht nur freie Humussäuren, sondern auch einige Humussäure-Salze auflöst.

2) *R. Albert*: Prakt. Chem. 70, 509 ff.



Lithiumphosphat nicht wasserlöslich ist, und infolgedessen die Wirkung auf freie Humussäuren erst nach einigen Tagen bemerkbar wird.

Die *Baumann* und *Gullysche*<sup>1)</sup> *Methode* ist sehr empfindlich, nach dieser Methode kann man nicht nur die Humussäuren in den Böden, sondern auch die saure Reaktion der durch Bodenkolloide absorbierten Tonerde- oder Eisenverbindung feststellen. Die *Loewische*<sup>2)</sup> *Methode* ist ebenfalls sehr empfindlich und zwar lässt sich nicht nur die von Humussäure stammende Acidität des Bodens, sondern auch die von den durch Bodenkolloide absorbierten Tonerde- resp. Eisenverbindungen herrührende nachweisen.

Der Verfasser empfiehlt folgende von ihm selbst herrührende Methode: *Man gibt eine Bodenprobe von 5 g in eine Reagenzröhre und setzt eine 10%ige Kaliumnitritlösung tropfenweise hinzu, sodass der Boden nur mässig angefeuchtet wird. Das  $KNO_2$  muss chemisch rein sein, besonders frei von  $K_2CO_3$* <sup>3)</sup> Die Oeffnung der Röhre wird mit Watte verschlossen, aus deren Mitte ein Streifen Jodkalium-Stärkepapier herabhängt. Nach kurzer Zeit kann man an der Intensität der blauen Färbung verschiedene Grade von Bodenacidität erkennen.

Diese Methode ist sehr praktisch und empfindlich, und die Acidität des Bodens sowohl die aus Humussäuren als auch die von den durch Bodenkolloide absorbierten Tonerde- resp. Eisenverbindungen stammende kann leicht erkannt werden.

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1) Naturw. Zeitschr. f. Forst- u. Landwirtschaft, München 1908 I. n. ff. Die Methode besteht darin, auf je 3 g Boden eine Flüssigkeit von 100 ccm Wasser, in der 2 g KJ und 0.1 g  $KJO_3$  gelöst worden sind, zu giessen, zeitweilig umzuschütteln, nach 15 Minuten zu filtrieren d. verdünnte Stärke zuzusetzen. Hierauf lässt sich an der Intensität der Färbung die verschiedenen Bodenaciditätsgrade erkennen.

2) Zeitschr. f. d. landw. Versuchsw. i. Oesterr; 1909, 462.

Man führt die Reaktion so aus, dass man etwa 10 g Boden mit ebensoviel einer 1% igen frisch bereiteten Lösung von Jodkalium 5-10 Minuten im kochenden Wasserbad im kleinen locker verschlossenen Kölbchen behandelt, dann einige Tropfen einer etwa 1% igen Lösung von salpetrigsaurem Kali zufügt, schüttelt und nun einige Tropfen frisch bereiteten Stärkeklisters zugibt und dann rasch abkühlt.

3)  $KNO_2$  ist dem  $NaNO_2$  vorzuziehen.

Durch obige Methoden kann man noch nicht den Grund der Bodenacidität erkennen, während folgende vom Verfasser herrührende Methode den Grund sofort erkennen lässt. Man bringt eine Probe des Bodens<sup>1)</sup> in eine Uhrschaale und setzt wenige neutrale KCl-Lösung zu; nach einigen Minuten wird die *Reaktion der Lösung* mit Lakmuspapier geprüft. Die saure Reaktion wird aus den durch Bodenkolloide absorbierten Tonerde- oder Eisenverbindungen stammen.

Um die Empfindlichkeit der drei Methoden *Baumann u. Gully*, *Loew* und des Verfassers *Kaliumnitritmethode* zu vergleichen, hat der Verfasser mit verschiedenen organischen Säuren und einigen sauren Salzen die niedrigste Grenze der Reaktion festgestellt mit folgendem Resultat:

Die niedrigste Grenze der Reaktion (%)

Proben	Loewsche Methode.	Baumann u. Gullysche Methode.	Kaliumnitritmethode.
Ameisensäure ... ..	0,03	0,0008	0,004
Essigsäure ... ..	0,05	0,0009	0,004
Milchsäure ... ..	0,07	0,0020	0,010
Buttersäure ... ..	0,09	0,0020	0,010
Lösl.-Humussäuren ...	—	0,0030	0,060
Al-Chlorid ... ..	0,05	0,005	0,007
Al-Sulfat ... ..	0,06	0,004	0,008
Saure K-Sulfat ... ..	0,07	0,004	0,020

Aus obigen Resultaten ersehen wir, dass die Säuren eine desto stärkere Reaktion aufweisen, je weniger Kohlenstoffatome sie im Molekül enthalten.

### BESTIMMUNG DER BODENACIDITÄT.

Es sind viele Bestimmungsmethoden über die von Humussäuren herrührende Bodenacidität vorgeschlagen worden, vor allem die von *Müntz*,

1) Der wässrige Extrakt des Probebodens muss vorher mit Lakmuspapier geprüft werden ob wasserlösliche, saure Substanzen vorhanden sind.

*Tacke, Schüchting, Hopkins, Veitch* und *Albert*, aber alle diese sind nicht ganz einwandfrei.

Die *Müntzsche Ammoniakmethode*<sup>1)</sup> ist schon von vielen Autoren dahingehend kritisiert worden, dass Ammoniak nicht nur freie Humussäuren auflöst, sondern auch neutrale Salze der Humussäuren, infolgedessen man nicht genau die Bodenacidität bestimmen kann. Aber die Methode ergibt doch ein praktisch verwendbares Resultat und ist in den Vereinigten Staaten und in Japan als offizielle Methode angenommen worden.

Die *Tackesche*<sup>2)</sup> *Methode* erfordert zu viel Zeit, und man muss sie daher als etwas unpraktisch bezeichnen. *Veitch*<sup>3)</sup> bemerkt, dass nicht nur mit saurem Boden sondern auch mit Calciumcarbonat enthaltendem, alkalischen Boden Kohlensäuregas entwickelt wird, infolgedessen diese Methode nicht massgebend sein kann.

Die *Schüchtingsche*<sup>4)</sup> *Methode* besteht aus der verbesserten *Tackeschen* Methode, jedoch eignen sich beide nicht zur Bestimmung freier Humussäuren, weil benutztes Calciumcarbonat nicht nur auf freie Humussäuren sondern auch auf die durch Bodenkolloide absorbierten Tonerde- resp. Eisenverbindungen wirkt<sup>5)</sup>.

Die *Hopkinsche*<sup>6)</sup> *Natriumchloridmethode* wurde empfohlen, um die unlöslichen organischen Säuren in den Böden zu bestimmen. *Hopkins* glaubt, dass sich die Humussäuren in den Böden mit den Basen in den neutralen Salzen verbinden und dabei die entsprechenden mineralischen Säuren oder sauren Salze entstehen. Aber wie schon von *Veitch*<sup>7)</sup> bemerkt worden ist, findet keine Reaktion statt zwischen Natriumchlorid und Humussäuren. *Veitch* hat weiter erklärt, dass freie Salzsäure nicht im

1) Encyclopédie chimique 4, 182.

2) Chemiker Zeitung 1897. 21: 174.

3) Journal Amer. Chem. Soc. 1904, 26: 661

4) Zeitschr. für angew. Chem. 21: 151/1908

5) Wie ich schon oben erwähnt habe, stammt die Bodenacidität der Moorböden oder Humusböden nicht immer allein aus freien Humussäuren, sondern man findet darin auch manchmal von durch Bodenkolloide absorbierten Tonerde- resp. Eisenverbindungen stammende.

6) Bulletin No. 73. Bureau of Chemistry U.S. Dept. of Agric.

7) Journ. of the Amer. Chem. Soc. 1904: 637.

Boden entstehen kann und die saure Reaktion des Filtrats durch Zusatz von Natriumchloridlösung zu sauren Böden erhalten wird, was auf das durch die Umsetzung des Natriumchlorids mit dem Aluminiumsilikat der neutralen Silikate entstehende Aluminiumchlorid zurückzuführen ist. Noch weiter hat sich *Veitch* geäußert, dass es zwei Sorten von Bodenacidität gibt: (1) Die *aktive* oder *wirkliche Acidität* entsteht aus etwas löslichen organischen und anorganischen Säuren sowie aus sauren Salzen. (2) Die *inaktive* oder die *negative Acidität* stammt wahrscheinlich einesteils aus leicht zersetzbaren neutralen, wasserhaltigen oder kolloidalen Silikaten und andernteils aus verschiedenen nicht sauer reagierenden colloidalen Humusstoffen.<sup>1)</sup> Ausserdem soll die letzte Gruppe *neutrale Reaktion* auf gewöhnliche Indikatoren haben, aber diese Gruppe besitzt eine starke Affinität für Na, K, Ca und Mg, und ein Teil der Bodenabsorption wird dieser Affinität zugeschrieben.

Des Verfassers Meinung nach ist aber die *Veitch'sche* Hypothese auch nicht richtig, weil, wie vom Verfasser oben mitgeteilt wurde, stark saurer Mineralboden durch Zusatz von neutraler Salzlösung einen stärker sauer reagierenden Extrakt gibt, während dies bei den neutralen Böden nicht der Fall ist.

Die *Hopkinsche* Methode ist im Jahre 1905 in der Versammlung der Agrikulturchemiker in Washington U.S. als vorläufige Methode für die Bestimmung der Bodenacidität adoptiert worden, aber die Methode hat keine Bedeutung für die Bestimmung der freien Humussäuren im Boden.

Die Methode passt auch nicht für die Bestimmung der Bodenacidität, die aus den durch Bodenkolloide absorbierten Tonerde- resp. Eisenverbindungen stammt, weil wie schon seit langem bekannt und vom Verfasser auch oben bemerkt ist, Natriumsalze weniger im Boden absorbiert werden als Kalium- oder Ammoniumsalze und infolgedessen die Bodenacidität mit NaCl-Lösung viel weniger Ausschlag gibt, als mit KCl oder NH<sub>4</sub>Cl-Lösung.

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1) Unlösliche Stoffe mit Säurecharakter, d.h. saure Hydroxylgruppen würden sich allerdings ähnlich verhalten.

Die *Veitchsche Kalkwassermethode*<sup>1)</sup> ist nicht nur zeitraubend, sondern ist es auch die Endreaktion sehr unregelmässig, so dass sie nicht als praktisch bezeichnet werden kann. Die *Albertsche Barytmethode*<sup>2)</sup> kann auch nicht als eine richtige Humussäurebestimmungsmethode betrachtet werden, weil Baryt nicht nur auf freie Humussäuren, sondern auch auf die durch Bodenkolloide absorbierten Tonerde- resp. Eisenverbindungen wirkt und noch weiter die Methode ungleicher Destillationsdauer verschiedene Resultate ergibt, weshalb das Resultat nicht als recht vertrauensvoll betrachtet werden kann.

### NEUE METHODE ZUR BESTIMMUNG DER BODENACIDITÄT, DIE AUS DEN DURCH BODENKOLLOIDE ABSORBIERTEN TONERDE- RESP. EISENVERBINDUNGEN STAMMT.

1. Prinzip: Wenn verschiedene Salzlösungen zu sauren Mineralböden zugesetzt werden, wird Aluminium oder Eisen, das in den Bodenkolloiden absorbiert behalten ist, durch die Base in der Salzlösung verdrängt, und dabei werden die entstehenden löslichen sauer reagierenden Verbindungen, z. B. Aluminiumchlorid, mit Normal-Alkalilösung titriert und es wird die Bodenacidität bestimmt.

2. Verfahren: 100 g lufttrockener Boden in einen ca. 600 ccm fassenden Kolben geschüttet, 250 ccm normal KCl-Lösung zugefügt, zeitweise umgeschüttelt, nach fünf Tagen oder nach einstündiger Schüttelung mit dem Apparat von der überstehenden Flüssigkeit 125<sup>3)</sup> ccm entnommen, dann gekocht, um dadurch das Kohlendioxyd entweichen zu lassen und mit 1/10 n NaOH-Lösung titriert, wobei man Phenolphthalein als Indikator benutzt.

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1) Journal Amer. Chem. Soc. 1904: 673

2) Zeitschrift für angew. Chem. 1909: 533.

3) Es ist praktisch die Hälfte von 250 cc + hygroskopisches Wasser im Boden wegzunehmen.

3. Die Berechnung der Totalbodenacidität<sup>1)</sup>: Wenn man 125 ccm von der Flüssigkeit nach obigem Verfahren genommen und titriert hat, wird die gleiche Menge frischer Flüssigkeit wieder der Bodenmenge zugesetzt. Nach abermaligem 5-tägigen Stehenlassen unter zeitweiligem Umschütteln, oder nach einstündigem Schütteln, wird wieder 125 ccm von der Flüssigkeit genommen und titriert, hierauf wiederholt man dieses Verfahren so lange, bis sich keine Bodenacidität mehr vorfindet.

Wenn man bezeichnet:

$$\begin{array}{ll} y_1 = \text{ccm von 1. Titration} & a_1 = y_2 - \frac{1}{2}y_1 \\ y_2 = \text{,, ,, 2. ,,} & a_2 = y_3 - \frac{1}{2}y_2 \\ y_3 = \text{,, ,, 3. ,,} & a_3 = y_4 - \frac{1}{2}y_3 \\ y_4 = \text{,, ,, 4. ,,} & a_n = y_{n+1} - \frac{1}{2}y_n \\ y_n = \text{,, ,, n. ,,} & \end{array}$$

So ergibt sich folgendes praktische Verhältnis:

$$K = \frac{a_2}{a_1} = \frac{a_3}{a_2} = \frac{a_4}{a_3} \dots \dots \frac{a_n}{a_{n-1}}$$

Hieraus kann man die Totalbodenacidität berechnen wie folgt:

Die Acidität beim ersten Mal in Lösung =  $2 y_1$

Die gesamte Acidität bei jedem Male hinzugefügt  $2 (a_1 + a_2 + a_3 \dots a_n)$   
 $= 2 a_1 (1 + K + K^2 + K^3 \dots \dots K^{n-1})$

$$\begin{aligned} \text{Totalacidität } S &= 2y_1 + 2 \sum_{n=1}^n a_n \\ &= 2y_1 + 2 a_1 \sum_{n=1}^n K^{n-1} \\ &= 2y_1 + 2a_1 \left( \frac{1 - K^n}{1 - K} \right) \end{aligned}$$

Da K kleiner als 1 ist, wenn man n als infinit betrachtet ( $n = \infty$ ), ergibt sich folgende:

$$S = 2 \left( y_1 + \frac{a_1}{1 - k} \right)$$

1) Hier möchte der Verfasser seinen herzlichen Dank den Herren Professor Dr. T. Terao, Prof. Dr. T. Okada und Dr. M. Fuji für ihre wertvolle Hilfe zur Berechnung der Totalbodenacidität ausdrücken.

Der Verfasser hat mit dem *Chichibu*-paläozoischen lehmigen sauren Tonboden aus *Yoshino* je 10 Serien Titrationsen ausgeführt und nach der obigen Formel die Totalacidität berechnet, dann wurde diese mit der gefundenen verglichen wie folgt:

$$\begin{array}{ll}
 Y_1 = 36,64 \text{ ccm} & a_1 = Y_2 - \frac{1}{2} Y_1 = 2,600 \\
 Y_2 = 20,92 \text{ ,,} & a_2 = Y_3 - \frac{1}{2} Y_2 = 2,110 \\
 Y_3 = 12,57 \text{ ,,} & a_3 = Y_4 - \frac{1}{2} Y_3 = 1,765 \\
 Y_4 = 8,05 \text{ ,,} & a_4 = Y_5 - \frac{1}{2} Y_4 = 1,255 \\
 Y_5 = 5,28 \text{ ,,} & a_5 = Y_6 - \frac{1}{2} Y_5 = 0,930 \\
 Y_6 = 3,57 \text{ ,,} & a_6 = Y_7 - \frac{1}{2} Y_6 = 0,725 \\
 Y_7 = 2,51 \text{ ,,} &
 \end{array}$$

$$\frac{a_2}{a_1} = 0,81; \quad \frac{a_3}{a_2} = 0,84; \quad \frac{a_4}{a_3} = 0,71; \quad \frac{a_5}{a_4} = 0,74;$$

$$\frac{a_6}{a_5} = 0,78; \quad \text{durchschnittlich } K = 0,78 = \text{rund } 0,8$$

$$S = 2 \left( y_1 + \frac{a_1}{1 - k} \right) = 2 \left( 36,64 + \frac{2,60}{1 - 0,8} \right) = 99,28 \text{ ccm}$$

Durch wiederholte Titration mit demselben Boden, bis der dabei erhaltene Extrakt fast neutral geworden ist, hat der Verfasser die Totalacidität von 99.17 ccm gefunden.

$$\text{Totalacidität.} \dots \dots \dots \left\{ \begin{array}{l} \text{Berechnet} = 99,28 \text{ ccm} \\ \text{Gefunden} = 99,17 \text{ ccm} \end{array} \right.$$

Die berechneten sowie gefundenen Totalaciditäten von verschiedenen Böden und der Wert von (K) wurden gefunden wie folgt:

Boden aus	Geologische Formation	Bodenarten	Totalacidität		
			gefunden	berechnet (ccm)	Wert von K
<i>Nara (Ikoma)</i>	Granit	Sand	21,52	20,52	0,90
<i>Niigata</i>	Alluvium	Lehm	37,07	37,80	0,85
<i>Gifu</i>	Alluvium	Lehm	28,15	27,40	0,85
<i>Nara (Yoshino)</i>	Paläozoisch	lehmiger Ton	96,42	96,20	0,80
<i>Kumamoto</i>	Mesozoisch	Ton	72,82	72,36	0,85

Die Uebereinstimmung der gefundenen und berechneten Zahlen den Totalacidität beweist die Richtigkeit der Formel und kann man in der Praxis den durchschnittlichen Wert von  $K=0,85$  benützen.

Bei obiger Methode muss man mindestens zwei Titrations ausführen und die Differenz  $a_1$  zwischen der Menge von 1/10 n NaOH Lösung bei der zweiten Titration und der halben Menge bei der ersten berechnen.

Wenn ein bestimmtes Verhältnis zwischen der Totalacidität und dem Ergebnis bei der ersten Titration besteht, kann man die Bodenacidität bei einmalige Titration bestimmen. Die Totalacidität und das Ergebnis der ersten Titration wurde mit zweiunddreissig verschiedenen Böden festgestellt und das Verhältnis zwischen beiden berechnet, wobei sich folgende durchschnittliche Zahlen ergaben :

$$\frac{\text{Totalacidität}}{\text{i. Titration nach 1 Tage}} = 3.49 = \text{rund } 3.5$$

$$\frac{\text{Totalacidität}}{\text{i. Titration nach 5 Tagen}} = 3.07 = \text{rund } 3.0$$

Wenn man diese durchschnittlichen Zahlen verwendet, so kann man leicht die approximale Totalacidität berechnen.

Der Verfasser hat zur praktischen Verwendung zwei Tabellen dargestellt, von denen die eine zu jedem gefundenen Grade der Totalacidität je die entsprechenden Mengen des Calciumkarbonats und Aetzkalks und die erforderlichen Mengen von beiden zur Neutralisation pro 100 kg Boden angibt, und die andere zum gefundenen Gewicht des 100 ccm lufttrocknen Bodens das entsprechende Gewicht des 10 cm tiefen Bodens pro ha. enthält.

Um das Resultat der obigen Aciditätsbestimmungsmethode auf seine Richtigkeit zu prüfen, wurden die drei folgenden humusarmen Böden mit der berechneten Menge von  $\text{CaCO}_3$  gemischt, worauf von Zeit zu Zeit die Reaktion untersucht wurde.

Boden aus	Bodenarten	Totalacidität	Berechnete Menge von $\text{CaCO}_3$
<i>Yoshino</i>	Lehmiger Ton	109,92 ccm	0,550 g
<i>Shiga</i>	Ton	55,56 „	0,278 „
<i>Ikoma</i>	Lehmiger Sand	27,15 „	0,136 „



Je 100 g Boden wurden mit der berechneten Menge von  $\text{CaCO}_3$  gemischt, mit Wasser angefeuchtet und unter zeitweiligem Umrühren 78 Tage lang stehen gelassen. Hierauf wurde die Reaktion auf Lackmuspapier geprüft, dann so viel Wasser darauf gegossen, dass dasselbe den Boden bedeckte, es diesmal 87 Tage stehen gelassen und ebenfalls der Boden hin und wieder umgeschüttelt. Während dieser 87 Tage wurde die Reaktion dreimal geprüft, nämlich nach 10, 27 und endlich nach 87 Tagen mit nachfolgendem Resultat:

Boden aus	$\text{CaCO}_3$ verwendet g	Reaktion des Bodens			
		Nach 78 Tagen	Breizustand		
			n. 10 Tagen	n. 27 Tagen	n. 87 Tagen
<i>Yoshino</i> ( <i>Nara</i> )	$\frac{1}{2}$ von der berechn. Menge = 0,275	stark sauer	sauer	schw. sauer	schw. sauer
	$\frac{3}{4}$ " " " = 0,413	sauer & alkalisch	schw. sauer & alkalisch	neutral	neutral
	1/1 " " " = 0,550	do	do	schw. alkalisch	schw. alkal.
	5/4 " " " = 0,688	do	do	alkalisch	alkal.
	3/2 " " " = 0,825	do	do	do	do
	2/1 " " " = 1,100	do	do	do	do
<i>Shiga</i>	$\frac{1}{2}$ von der berechn. Menge = 0,139	stark sauer	sauer	sauer	sauer
	$\frac{3}{4}$ " " " = 0,209	do	sauer	schw. sauer	schw. sauer
	1/1 " " " = 0,278	sauer	schw. sauer	neutral	neutral
	5/4 " " " = 0,345	sauer & alkalisch	schw. sauer & alk.	schw. alkal.	schw. alkal.
	3/2 " " " = 0,417	do	do	alkal.	alkal.
	2/1 " " " = 0,556	do	do	do	do
<i>Ikoma</i> ( <i>Nara</i> )	$\frac{1}{2}$ von der berechn. Menge = 0,068	sauer	sauer	sauer	sauer
	$\frac{3}{4}$ " " " = 0,102	do	do	schw. sauer	schw. sauer
	1/1 " " " = 0,136	do	schw. sauer	do	neutral
	5/4 " " " = 0,170	sauer & alkalisch	schw. sauer & alk.	neutral	neutral
	3/2 " " " = 0,204	do	do	alkalisch	alkalisch
	2/1 " " " = 0,272	do	do	do	do

Dieselben drei Bodenproben wurden mit verschiedenen Mengen von Aetzkalilösung unter zeitweiligem Umschütteln behandelt, und nach 7 Tagen die Reaktion des Bodens geprüft. Resultat wie folgt:

Boden aus	KOH verwendet	Reaktion der Bodens
<i>Yoshino</i> ( <i>Nara</i> )	$\frac{3}{4}$ von der berechneten Menge	sauer
	1/1 " " " "	neutral
	5/4 " " " "	alkalisch
<i>Shiga</i>	$\frac{1}{2}$ von der berechneten Menge	stark sauer
	$\frac{3}{4}$ " " " "	sauer
	1/1 " " " "	schw. sauer
	5/4 " " " "	neutral
	3/2 " " " "	alkalisch
	2/1 " " " "	do
<i>Ikoma</i> ( <i>Nara</i> )	$\frac{1}{2}$ von der berechneten Menge	sauer
	$\frac{3}{4}$ " " " "	schw. sauer
	1/1 " " " "	neutral
	5/4 " " " "	alkalisch
	3/2 " " " "	do
	2/1 " " " "	do

Aus obigem Ergebnis ersehen wir, dass die Acidität der humusarmen sauren Böden mit der nach der Methode des Verfassers berechneten Menge von KOH oder  $\text{CaCO}_3$  fast gang neutralisiert.

Weiter hat der Verfasser viele Topfversuche<sup>1)</sup> mit verschiedenen Böden und verschiedenen Pflanzen ausgeführt, um die optimale Menge von Kalk zu bestätigen, und das Ergebnis mit berechneter Menge ist folgendes:

1) Die näheren Erklärungen werden später vom Verfasser mit dem Resultat anderer verschiedener Topfversuche mitgeteilt.

Boden	Optimale Menge von $\text{CaCO}_3$	Berechnete Menge von $\text{CaCO}_3$
<i>Niigata</i> Boden... ..	1,80 g	1,60 g
<i>Gifu</i> Boden ... ..	1,30 „	0,93 „
<i>Shiga</i> Boden ... ..	2,80 „	2,56 „
<i>Yoshino</i> Boden... ..	3,40 „	3,78 „

Die obigen Resultate zeigen, dass die KCl-Methode bei Bestimmung der Acidität des Bodens, die aus den durch Bodenkolloide absorbierten Tonerde- resp. Eisenverbindungen stammt, richtige Resultate liefert und man sie mit Sicherheit in der Praxis verwenden kann.

### DIE BODENACIDITÄT UND DER KALKFAKTOR.

Es ist in neuerer Zeit gezeigt worden, dass ein Optimalertrag unter anderen auch von einem gewissen Mengen-Verhältnis zwischen CaO und MgO im Boden abhängt. Zahlreiche Versuche lassen nicht daran zweifeln. *Loew* hat weiter beobachtet, dass die Schädlichkeit des Ueberschusses an Magnesia sehr gross ist, wenn die Reaktion der Nährlösung sauer ist.

Auf des Verfassers Vorschlag hat *Sakamoto* vor einiger Zeit drei verschiedene Böden, welche viele Jahre hinter einander gekalkt worden sind, und drei von gleichem Ursprung jedoch ohne Kalkung und ohne kultiviert gewesen zu sein, untersucht mit folgendem Ergebnis:

Boden I aus	CaO	MgO	CaO: MgO	
a) <i>Ikoma</i> ( <i>Nara</i> ) ...	{ mit Kalk	0,291	0,140	2,09
	{ ohne „	0,121	0,159	0,76
b) <i>Yoshino</i> I ( <i>Nara</i> ) ...	{ mit Kalk	0,381	0,350	1,09
	{ ohne „	0,100	0,515	0,19
c) <i>Yoshino</i> II ( <i>Nara</i> ) ..	{ mit Kalk	0,364	0,416	0,88
	{ ohne „	0,073	0,346	0,20

Aus der obigen Tabelle ersehen wir, dass jene drei Böden ursprünglich sehr wenig Kalk enthalten und bei den Böden b und c der Kalkgehalt nur ungefähr ein Fünftel des Magnesiagehaltes beträgt. Es ist nun von Interesse zu beobachten, dass der Boden b durch die Kalkung den für Getreidearten günstigsten Kalkfaktor 1 fast genau erreichte, während bei a die Zahl etwas überschritten und bei c noch nicht ganz erreicht wurde. Immerhin sind alle drei Verhältnisse dem günstigsten Kalkfaktor noch sehr nahe.

Die geologischen Formationen, die Pflanzen, die jährlichen Mengen des gebrannten Kalks und die Anzahl der Jahre der Kalkung sind wie folgt:

Boden aus	Geologische Formation	Boden arten	Pflanzen		Jährliche Anwendung des Kalks pro ha.	Anzahl der Jahre der Kalkung
			Sommer	Winter		
<i>Ikoma (Nara) ...</i>	Granit	Sandlehm	Reis	Nackt-Gerste	2300-2600 Kg	15
<i>Yoshino I (Nara)..</i>	<i>Chichibu-Paläozoisch</i>	Lehmton	Reis	—	do	15
<i>Yoshino II (Nara)..</i>	Tertiär	Lehmton	Reis	Nackt-Gerste	do	20

Später hat der Verfasser gefunden, dass jene unkultivierten Böden eine starksaure Reaktion hatten, die kultivierten und gekalkten Böden hingegen eine neutrale.

Das Bestimmungsresultat der Bodenacidität ist wie folgt:

Boden aus	Boden acidität.
a) <i>Ikoma (Nara)</i>	{ mit Kalk ... .. neutral
	{ ohne „ ... .. 27,25 ccm
b) <i>Yoshino I (Nara)</i>	{ mit Kalk ... .. neutral
	{ ohne „ ... .. 31,75 ccm
c) <i>Yoshino II (Nara)</i>	{ mit Kalk ... .. neutral
	{ ohne „ ... .. 28,50 ccm

Es ist auffallend, dass der Unterschied der Reaktion zwischen den kultivierten und unkultivierten Böden sehr gross ist. Man musste daher diesen Boden kalken, erstens um die saure Reaktion zu verhindern und zweitens, um den Kalkfaktor aufzubessern.

Der Verfasser hat viele saure Böden inbezug auf CaO und MgO-Gehalt untersucht und bemerkt, dass je stärker sauer die Reaktion eines Bodens ist, desto weniger Kalk er enthält, wie folgende Tabelle durchschnittlich ergibt:

Reaktion des Bodens	Silikatacidität des Bodens	Kultivierter Boden		Unkultivierter Boden	
		Anzahl der Bodenproben	Durchschnittlicher Kalkfaktor	Anzahl der Bodenproben	Durchschnittlicher Kalkfaktor
Sehr stark sauer	> 20 ccm	8	0.81	15	0.54
Stark sauer ...	5-20 „			20	0.65
Sauer ... ..	1-5 „	13	0.88	11	0.96
Schwach sauer..	< 1.0 „	12	1.33	29	1.04

#### ZUSAMMENFASSUNG der ERGEBNISSE.

1) Die Bodenacidität, die in der Praxis eine grosse Rolle spielt, stammt nicht nur von den Humussäuren im Humusboden her, sondern kann auch auf die durch Bodenkolloide absorbierten Tonerde- und Eisenverbindungen im Mineralboden zurückgeführt werden.

2) Da die Humussäuren ebenso wie andere mineralische Kolloide in der Ackererde Tonerde und Eisen-Salze absorbieren und dieselben durch neutrale Salzlösungen wiederum in Lösung zu bringen gestatten, so dürfte wohl die durch Kolloide absorbierte Tonerde und das Eisen nicht nur für die Acidität der Mineralböden, sondern auch für diejenige der humussäuren Böden eine ausschlaggebende Rolle spielen.

3) Die schädliche Einwirkung<sup>1)</sup> der durch Bodenkolloide absorbierten Tonerde- resp. Eisenverbindungen auf die Vegetation beruht hauptsächlich auf den durch Anwendung des Salzdüngermittels entstehenden sauer reagierenden löslichen Tonerde- resp. Eisenverbindungen.

1) Die schädliche Wirkung der löslichen Tonerde- resp. Eisenverbindungen auf die Vegetation wurde vom Verfasser an verschiedenen Pflanzen untersucht; über das Resultat wird ebenso wie über andere Verbesserungsversuche des Sauerbodens späterhin berichtet werden.

4) In *Japan* und *Korea* gibt es viele sauer reagierende Böden: über drei viertel der Bödenproben beider Länder reagieren sauer und bei mehr als der Hälfte davon beruht die Bodenacidität auf den durch Kolloide absorbierten Tonerde- und Eisenverbindungen.

5) In Bezug auf geologischen Ursprung haben Böden von mesozoischer Formation am häufigsten saure Reaktion, dann folgen tertiäre, paläozoische und Diluvium-Böden. Die Böden des Alluviums reagieren am wenigsten sauer und zwar ist der Prozentsatz der sauren Böden aus mesozoischer Formation etwa zweimal grösser als der von Alluvium.

6) Böden aus sogenannten sauren Gesteinen zeigen einen höheren Prozentsatz der sauren Böden als die Böden aus basischen Gesteinen; die Böden aus vulkanischer Asche ergeben den geringsten Prozentsatz.

7) Der Nachweis der Bodenacidität mit Lakmuspapier ist am einfachsten, jedoch sind die *Baumann-* und *Gullysche*, sowie die *Loewische* Methode genauer und empfindlicher, die *Kaliumnitrit-Methode* des Verfassers ist allerdings ebenso genau wie diese beiden und zugleich viel praktischer.

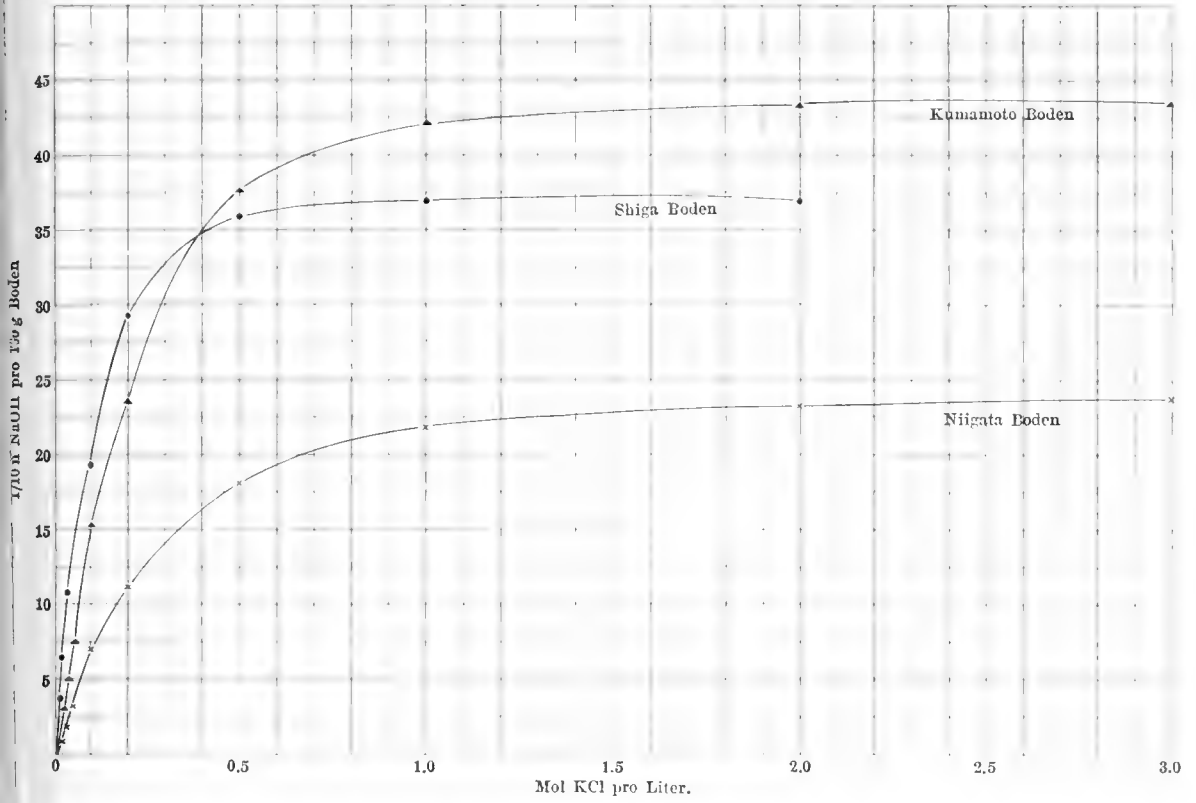
8) Da die durch Kolloide absorbierte Tonerde- und Eisenverbindungen im Boden die charakteristische Eigenschaft haben, in neutralen Salzlösungen eine saure Reaktion zu erzeugen, so kann man mit der *Kaliumchloridmethode* des Verfassers eine solche Bodenacidität nicht nur nachweisen, sondern auch genau bestimmen. Kaliumchlorid kann hierbei nicht durch Natriumchlorid ersetzt werden.

9.) Saure Böden enthalten im allgemeinen wenig Kalk und ihr Kalkfaktor ist meistens ungünstig, da die Magnesia überwiegt.

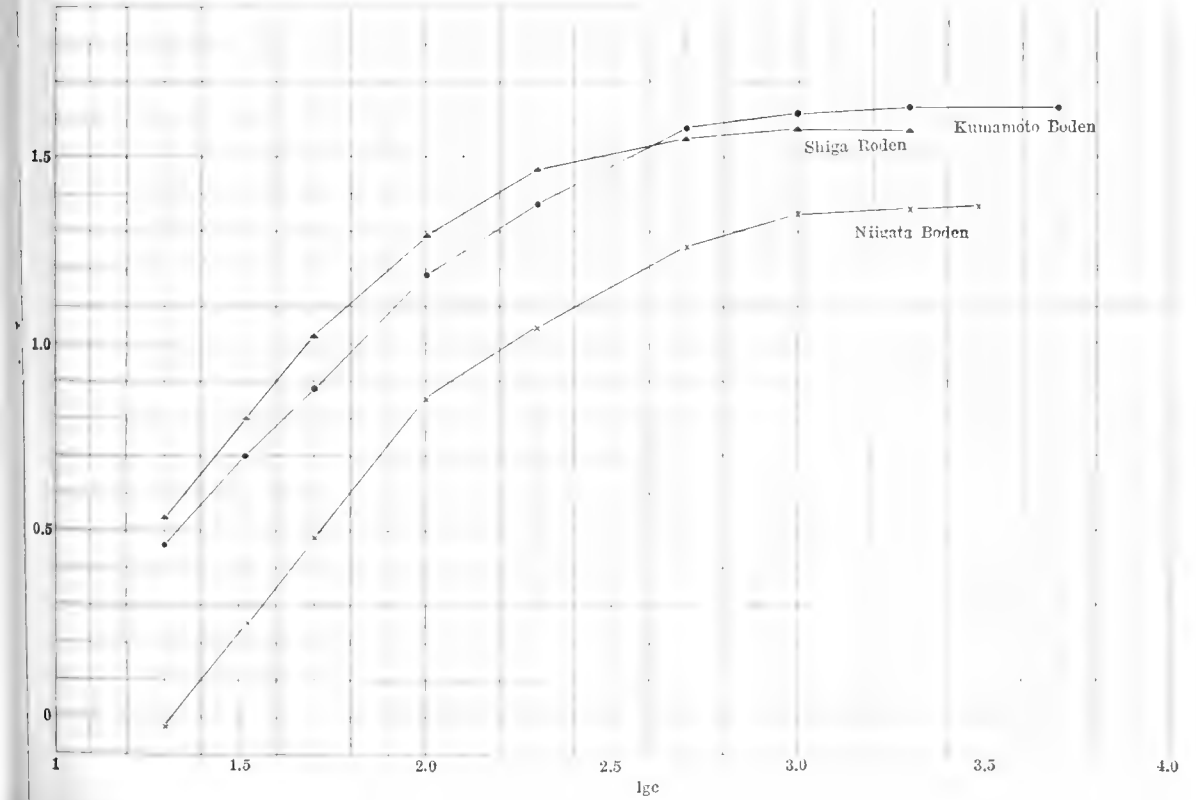
Zum Schluss möchte der Verfasser seinen herzlichen Dank den Herren Direktor Prof. Dr. *Y. Kozai* und Prof. Dr. *O. Loew* für ihren wertvollen Rat und den Herren *Y. Sakamoto*, *M. Yamamoto* und *G. Matsubara* für ihre analytische Hilfe bei dieser Untersuchung ausdrücken.

Besonders ist es dem Verfasser eine angenehme Pflicht, Herrn Prof. Dr. *R. Zsigmondy* für seine freundliche Unterstützung bei den Absorptionsversuchen seinen Dank auszusprechen.

I.



II.







# Über die Verwertung von Stengeln und Blättern der Süsskartoffelpflanze (*Ipomaea Batatas Lam.*) als Futtermittel.

VON

T. KATAYAMA.

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Die Kultur der Süsskartoffel ist bei uns von Südwest bis nach Mitteljapan verbreitet und findet sich vielfach auf solchen kleinen Inseln, die bei steilen Gebirgen kaum ebene Landflächen besitzen, was für die Reiskultur ungeeignet ist. Da jedoch die Kultur verhältnismässig nicht so intensiv ist und das Ackerfeld nur kurze Zeit beansprucht, so baut man diese Kartoffel auch ziemlich viel auf dem fruchtbaren Ackerboden. Die totale Kartoffelernte beträgt etwa 3,2 Millionen Tonnen, die von etwa 290,000 Hectar geerntet werden.<sup>1)</sup> Die Süsskartoffel wird hauptsächlich direkt zum Kochen verwendet, zum Teil zu Stärkemehl bearbeitet, und die Abfälle werden jetzt sehr gut für die Fütterung verwendet.

Die oberirdischen Pflanzenteile, namentlich die Stengel und Blätter, gedeihen sehr üppig, das ganze Feld bedeckend, sodass die grossen Mengen dieser Pflanzenteile den Landleuten mit ausgedehntem Süsskartoffelbau lästig fallen. Die abfallenden Stengel (es sind stets die Blätter damit eingeschlossen!), betragen durchschnittlich ca. 13 Tonnen pro Hectar. Trotzdem ist bisher denselben sehr wenig Beachtung geschenkt worden, ja man betrachtet sie vielmehr als einen blossen Ballast, dessen Verwendung immer Schwierigkeiten verursacht. In der Regel ackert man sie einfach gleich nach der Kartoffelernte unter, was noch durch die langen, schwer zerreisbaren Stengel auch nicht so einfach vonstatten geht.

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1) Statistical Report of the Department of Agriculture and Commerce 1912.

In Bezug auf die Verwendung der Stengel zu Fütterungszwecken glaubt man oft, dass die grünen Stengel für Haustiere, besonders für das Pferd ganz ungeeignet seien, da sie diätetisch ungünstig, namentlich stark abführend wirkten. Jedoch in einigen Gegenden werden tatsächlich das Milchvieh und die Schweine anhaltend mit grösseren Mengen von Stengeln gefüttert, so lange wie möglich in frischem Zustande, indem dabei nicht irgend eine schädliche Folge, sondern eine günstige Nährwirkung bemerkt wird. Aber man kann die Stengel nur deshalb gar nicht lange verfüttern, weil man gewöhnlich gezwungen wird, alle Kartoffeln auf einmal zu ernten, um für die Bestellung desnächst kommenden wichtigen Wintergetreides Platz zu machen.<sup>1)</sup> Jedenfalls wird im allgemeinen wahrgenommen, dass die Stengel, welche schon in den trockenen Zustand übergegangen sind, für die Tiere sehr wenig nachteilig, sogar ganz unschädlich sind. Trotzdem wird das Austrocknen derselben an der Luft auch deswegen von Landwirten nicht gern versucht, weil man für das so zeitraubende Trocknen der sehr wässrigen Stengel eine genügende Ackerfläche, worauf man dieselben zu legen hat, opfern muss, besonders weil es noch oft durch ungünstige Witterung verzögert wird. Auf einigen kleinen Inseln und in gebirgigen Gegenden in Westjapan trocknet man zwar die Stengel in kleinen Haufen an der Luft aus, indem man sie zumeist sehr lange, ja oft über 4 Wochen, einfach im Freien lässt, wonach man sie in der Scheune oder auf dem Dachboden für die Winterfütterung lagert. Da die Blätter dieser Pflanzen rascher dürr werden, als die Stengel und sehr leicht zerbröckeln, so bleibt nach einer so langen Zeit nicht viel mehr übrig als die nackten Stengel, und sie sehen nur wie eine nährarme Strohart aus.

## I. UEBER DAS TROCKNEN VON SUESSKARTOFFEL-STENGELN.

Es erscheint nun sehr wünschenswert, den Nährwert der Süsskartof-

1) In den nördlichen Gegenden Mitteljapans werden die Blätter oft schon einige Wochen vor der Kartoffelernte vom Frost beschädigt, und dieselben werden dann von Tieren nicht mehr gern aufgezehrt.

felstengel<sup>1)</sup> als Futtermittel festzustellen, welcher meines Wissens noch unbekannt ist, und ferner die zweckmässigen Konservierungsverfahren zu untersuchen. Um einige Versuche auf diesem Gebiete anzustellen, habe ich Mitte October 1908 eine grosse Menge Kartoffelstengel, die bei der Kartoffelernte auf unserem Versuchsfelde erhalten wurden, gesammelt und dieselben mit Hilfe der Schneidmaschine in kleine Stückchen von ca. 3–6 cm geschnitten. Die zerkleinerten Stengel wurden gut gemischt und in zwei gleiche Teile eingeteilt, um zweierlei Dauerfutter herzustellen.

Die eine Hälfte wurde auf Strohmatten sehr dünn ausgestreut und täglich bei Tage der freien Luft ausgesetzt. Es war immer gutes Wetter und noch ziemlich warm (13–19°C bei Tage), und die ganze Masse war nach 10 Tagen so gut abgewelkt, dass sie eine genügende Haltbarkeit als Dürrfutter gewonnen hatte. Die andere Hälfte wurde in einem kleinen trommelförmigen Teebereitungsapparate, der zur Verdunstung der gedämpften grünen Teeblätter dient, unter Leitung von Heissluftstrom gerollt, bis alle Stengelchen sehr gut getrocknet waren. Von 213 kg Kartoffelstengeln mit 12,52% Trockensubstanz habe ich 15,2 kg Lufttrockenstengel mit 87,64% und 14,9 kg getrocknete Stengel mit 88,53% erhalten.

Ausser diesem habe ich noch das Einsäuern der Stengel in einem Tongefäss versucht, worüber ich später sprechen möchte.

Was nun den äusseren Befund und die chemische Untersuchung der beiden Trockenstengel anbelangt, so ergab sich für die einzelnen Proben folgendes :

Lufttrockenstengel. Die Blätter hatten eine sehr dunkle Farbe und zerbröckelten sehr leicht, aber die Stengel wiesen ein hellbraunes Stroh auf, das jedoch viel dickfleischiger als das übliche war. Der Geruch war schwach aromatisch und erinnerte etwas an schwarzen Tee. Die chemische Analyse ergab folgende, auf Trockensubstanz berechnete Zusammensetzung :

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1) Untersuchungen über den Nährwert des gewöhnlichen Kartoffelkrautes wurden von *E. Wildt* (Landw. Jahrbücher 6. Bd, 1877) und von *H. Völz* u. *A. Bardrexl* (Landw. Jahrbücher 43. Bd., 1912) ausgeführt.

Organ.- Substanz %	Rohprotein %	N-freie Extraktstoffe %	Rohfett %	Rohfaser %	Eiweiss %
88.60	12.44	42.85	3.39	29.92	11.17

Getrocknete Stengel. Das Trockengut besass ein viel dunkleres Aussehen und enthielt mehr feine staubförmige Teilchen als die Lufttrockenstengel. Es hatte einen angenehmen, schwach karamelartigen Geruch, jedoch waren verbrannte Teile nicht wahrnehmbar. Die chemische Zusammensetzung war folgende :

Organ.- Substanz %	Rohprotein %	N-freie Extraktstoffe %	Rohfett %	Rohfaser %	Eiweiss %
90.04	11.04	46.90	3.46	28.64	9.78

Was nun die vorliegenden Ausnutzungsversuche anbetrifft, so war die Anordnung und Durchführung derselben die bei derartigen Untersuchungen übliche. Als Versuchstiere dienten zwei Hammel. Es wäre vielleicht am einfachsten gewesen, die Verdaulichkeit der Trockenstengel in der Weise festzustellen, dass man den Tieren ausschliesslich Stengel verabreicht hätte. Aber es schien nicht ratsam, die Stengel ohne Beifütterung von Stroh oder Heu den Tieren darzubieten, obwohl die ungünstige Beschaffenheit schon während des Trocknens stark geschwächt werden soll. Ich fing daher zunächst mit einer aus Dürrheu bestehenden Grundfütteration an, dann habe ich dieser in den übrigen Perioden die auf ihre Verdaulichkeit hin zu untersuchenden Trockenstengel zugelegt.

Die Versuchstiere waren in der gewohnten Weise mit Hartrichter und Kotbeutel angeschirrt und befanden sich während der ganzen Dauer der Versuche in den bekannten Zwangsställen. Nach 5-8 tägiger vorbereitender Fütterung wurde der eigentliche Versuch begonnen, der 10 Tage dauerte. Der Kot wurde frisch gewogen, der 10. Teil für die Analyse bei ca. 60°C getrocknet. Die Analyse erfolgte nach den üblichen Methoden; Rohfaser nach Weender-Verfahren, Reineiweiss nach Barnstein. Da die Tiere die vollständige Aufnahme der gewöhnlichen Fütteration von 1 kg Heu verweigerten, so wurde das Quantum auf bloss 750 Gramm herabgesetzt, um unter allen Umständen einen Futterrest zu vermeiden. Kochsalzgabe war stets 6 g.

Das Futter wies folgenden Gehalt an Trockensubstanz auf:

			Trockensubstanz			
			%	g.		
I.	Periode	750 g	Dürrheu	85.77	643.2	
II.	"	{	350 g	Dürrheu	85.77	300.2
			400 g	Lufttrockenstengel	87.64	350.6
III.	"	{	350 g	Dürrheu	85.77	300.2
			400 g	Getrocknete Stengel	88.53	354.1

Die an einzelnen Tagen in der ersten Periode erlangten Zahlen für die Mengen und die Trockensubstanz des Kotes, sowie für den Tränkwasserkonsum sind in den im Anhang befindlichen Tabellen zusammengestellt, aus welchen sich folgende Durchschnittswerte berechnen:

	Tränkwasserkonsum	Kot frisch	Kot trocken
Hammel I.	1127	520.6	278.5
„ II.	1359	625.5	298.2

Die Zusammensetzung des verfütterten Heues und des während der Grundfutterperiode von den einzelnen Tieren ausgeschiedenen Kotes war, auf Trockensubstanz bezogen, folgende:

	Heu	Kot	
		Hammel I	Hammel II
	%	%	%
Organische Substanz ...	87.88	79.58	80.16
Rohprotein ... ..	10.65	11.50	11.36
N-freie Extraktstoffe ...	43.98	46.90	44.20
Rohfett ... ..	1.71	2.67	2.85
Rohfaser ... ..	31.52	21.21	23.34
Eiweiss ... ..	9.87		

Berechnet man nun aus dem Futterkonsum die Verdauungskoeffizienten für die einzelnen Futterbestandteile, so ergeben sich folgende Werte:

	Trocken- substanz g	Organische Substanz g	Roh- protein g	N-freie Extrakt- stoffe g	Rohfett g	Rohfaser g
PERIODE I.						
Hammel I (Gewicht 62.0 kg)						
750 g Dür rheu ... ..	643.2	565.1	68.5	282.9	11.0	202.7
Im Kot ... ..	278.5	221.6	32.0	123.1	7.4	59.1
Verdaut im Ganzen :	364.7	343.5	36.5	159.8	3.6	143.6
Verdaut in Prozenten :	56.7	60.7	53.3	56.5	32.7	70.9
Hammel II (Gewicht 53.3 kg)						
Gesamtverzehr wie Hammel I...	643.2	565.1	68.5	282.9	11.0	202.7
Im Kot ... ..	298.2	239.0	33.9	127.1	8.5	69.6
Verdaut im Ganzen :	345.0	326.1	34.6	155.8	2.5	133.1
Verdaut in Prozenten :	53.7	57.7	50.6	55.1	23.0	65.7
Im Durchschnitt :	55.2	59.2	52.0	55.8	27.9	68.3

Das verfütterte Heu enthielt also nach diesem Versuche an verdau-  
lichen Nährstoffen in der Trockensubstanz :

Rohprotein	N-freie Extraktstoffe	Rohfett	Rohfaser	Eiweiss	Stärkewert <sup>1)</sup>
%	%	%	%	%	%
5.54	24.54	0.48	21.53	47.6	33.2

Die in der zweiten und dritten Periode erlangten Durchschnittswerte  
für die Kotausscheidung und den Tränkwasserkonsum waren folgende :

	Tränkwasserkonsum g	Kot frisch g	Kot trocken g
II. Periode Hammel I ...	889	535.6	293.1
„ II ...	1213	585.6	297.2
III. Periode Hammel I ...	1017	563.9	288.2
„ II ...	1178	573.3	294.5

1) Die Berechnung des Stärkewertes wurde ermittelt nach der in *Kellners Handbuch*  
„Die Ernährung der landw. Nutztiere“ 4. Auflage, S. 581 angegebenen Weise.

Bei der chemischen Analyse des Kotes wurden folgende, auf Trockensubstanz berechnete Zahlen erhalten:

	II. Periode		III. Periode	
	Hammel I. %	Hammel II. %	Hammel I. %	Hammel II. %
Organische Substanz.	81.91	83.51	83.19	83.83
Rohprotein ... ..	13.55	13.32	15.32	15.07
N-freie Extraktstoffe.	40.35	39.25	39.92	40.03
Rohfett ... ..	2.96	3.00	2.68	2.70
Rohfaser ... ..	25.04	27.94	25.26	26.03

Bringt man nun die Ausgaben im Kot von den Einnahmen in Futter in Abzug und berechnet den Teil der verdaulichen Nährstoffe, welcher aus dem Dürrheu stammt, so ergeben sich für die Verdauungskoeffizienten der betreffenden Trockenstengel folgende Werte:

(Siehe die Tabelle auf S. 48)

Wie aus vorstehenden Zahlen ersichtlich ist, weisen bei beiden Sorten von Stengeln die Verdauungskoeffizienten der einzelnen Nährbestandteile fast keine Unterschiede auf. Recht gut stimmen die Verdaulichkeit der stickstofffreien Nährstoffe miteinander überein, während die des Rohproteins stark abweicht. Es ist dies sicherlich auf die Temperatur, die bei dem Trocknen verwendet wurde, zurückzuführen; eine bekannte Tatsache,<sup>1)</sup> je höher die Temperatur ist, desto weniger verdaulich wird das Rohprotein. Die beiden Trockenstengel enthielten also die folgenden verdaulichen Nährstoffmengen in der Trockensubstanz:

	Lufttrockenstengel %	Getrocknete Stengel %
Rohprotein ... ..	5.54	2.89
N-freie Extraktstoffe ... ..	26.14	30.46
Rohfett ... ..	1.95	2.28
Rohfaser ... ..	16.19	16.01
Eiweiss ... ..	4.27	1.73
Stärkewert ... ..	32.6	35.9

1) O. Kellner. Die Ernährung der landw. Nutztiere 4. Auflage S. 261; J. Volhard, Landw. Versuchsstationen 58. Bd. 1903 S. 43; und Montanari, Zentralbl. für Agr. Chemie 1908 Heft 11.

	Trocken- substanz g	Organische Substanz g	Roh- protein g	N-freie Ex- traktstoffe g	Rohfett g	Rohfaser g
PERIODE II.						
Hammel I (Gewicht 61.2 kg)						
350 g Dürreheu ... ..	300.2	263.8	32.0	132.0	5.1	94.6
400 g Lufttrockenstengel... ..	350.6	310.6	43.6	150.2	11.9	104.9
Gesamtverzehr:	650.8	574.4	75.6	282.2	17.0	199.5
Im Kot ... ..	293.1	240.1	39.7	118.3	8.6	73.4
Verdaut im Ganzen:	357.7	334.3	35.9	163.9	8.4	126.1
„ von Dürreheu:	170.2	160.3	17.0	74.6	1.7	67.0
„ von den Luft- trockenstengeln:	187.5	174.0	18.9	89.3	6.7	59.1
Verdaut in Prozenten:	53.5	56.0	43.4	59.5	56.3	56.3
Hammel II (Gewicht 53.0 kg)						
Gesamtverzehr wie Hammel I..	650.8	574.4	75.6	282.2	17.0	199.5
Im Kot ... ..	297.2	248.2	39.6	116.7	8.9	83.0
Verdaut im Ganzen:	353.6	326.2	36.0	165.5	8.1	116.5
„ von Dürreheu:	161.0	152.2	16.1	72.7	1.1	62.1
„ von den Luft- trockenstengeln:	192.6	174.0	19.9	93.8	7.0	54.4
Verdaut in Prozenten:	55.0	56.0	45.6	62.5	58.8	51.9
Im Durchschnitt:	54.3	56.0	44.5	61.0	57.6	54.1
PERIODE III.						
Hammel I (Gewicht 60.0 kg)						
350 g Dürreheu ... ..	300.2	263.8	32.0	132.0	5.1	94.6
400 g Getrocknete Stengel ... ..	354.1	318.8	39.1	166.1	12.3	101.4
Gesamtverzehr:	654.3	582.6	71.1	298.1	17.4	196.0
Im Kot ... ..	288.2	239.8	44.2	115.0	7.8	72.8
Verdaut im Ganzen:	366.1	342.8	26.9	183.1	9.6	123.2
„ von Dürreheu:	170.2	160.3	17.0	74.6	1.7	67.0
„ von den getrock- neten Stengeln:	195.9	182.5	9.9	108.5	7.9	56.2
Verdaut in Prozenten:	55.3	57.2	25.3	65.3	64.3	55.4
Hammel II (Gewicht 52.0 kg)						
Gesamtverzehr wie Hammel I.	654.3	582.6	71.1	298.1	17.4	196.0
Im Kot ... ..	294.5	246.9	44.4	117.9	8.0	76.7
Verdaut im Ganzen:	359.8	335.7	26.7	180.2	9.4	119.3
„ von Dürreheu:	161.0	152.2	16.1	72.7	1.1	62.1
„ von den getrock- neten Stengeln:	198.8	183.5	10.6	107.5	8.3	57.2
Verdaut in Prozenten:	56.1	57.5	27.1	64.7	67.4	56.4
Im Durchschnitt:	55.7	57.4	26.2	65.0	65.9	55.9



Im allgemeinen dürfte der Lufttrockenstengel seiner Zusammensetzung und Verdaulichkeit, sowie auch seinem Stärkewert nach einem Dürrehu von mittler Güte, die *O. Kellner* in seiner Fütterungstabelle<sup>1)</sup> angibt, beinahe gleich kommen. Vergleicht man weiter denselben mit dem zu den vorliegenden Versuchen verwendeten Dürrehu, sowie mit dem gewöhnlich von unseren Landleuten für den Erhaltungszweck benützten Rohfutter, das nach *Kellnerschen* Untersuchungen<sup>2)</sup> folgende Nährwerte haben soll, so muss er, das Reisstroh an Güte übertreffend, wenigstens unter unseren japanischen Rohfutterarten als ein solches von sehr guter Sorte bezeichnet werden :

	Rohnährstoffe				Verdaul. Nährstoffe			
	Rohprotein	N-freie Extraktstoffe	Rohfett	Rohfaser	Rohprotein	N-freie Extraktstoffe	Rohfett	Rohfaser
	%	%	%	%	%	%	%	%
Gewöhnliches Heu No. I.	9.9	42.2	2.6	35.3	4.3	22.2	1.2	22.6
„ „ II.	12.2	42.3	3.1	33.2	7.4	24.3	1.5	21.7
„ „ III.	9.3	45.6	3.3	32.6	3.2	23.7	1.7	18.6
Im Durchschnitt :	10.5	43.4	3.0	33.7	5.0	23.4	1.5	21.0
Heu von unkultivierten Ländereien No. I.	8.9	40.0	3.4	40.4	3.6	17.5	1.5	26.1
Heu von unkultivierten Ländereien No. II.	7.0	42.5	3.3	40.5	1.6	17.5	1.3	25.6
Heu von Imperata arundinacea	10.8	35.7	2.8	42.4	5.6	16.0	1.1	23.7
Stroh vom Sumpfreis ...	6.8	24.8	2.2	48.7	3.2	8.8	0.9	28.3
„ „ Bergreis ...	6.8	32.1	2.2	40.4	3.0	9.3	1.1	22.3

Ausserdem habe ich bei der Verabreichung der Trockenstengel durchaus keine gesundheitsschädliche Wirkung derselben bemerkt, obwohl ich über 6 Wochen lang mit 400 Gramm die beiden Hammel gefüttert

1) Ebenda, S. 581.

2) Imperial University, College of Agriculture. Tokyo, Japan. Bulletin No. 2.

habe, die immer mit grosser Begierde frassen. Es erscheint deswegen sehr wünschenswert, die Stengel und Blätter der Süsskartoffel nicht als blossen Ballast zu betrachten, sondern als ein gutes Rauhfutter zu verwerten, besonders weil das Bedürfnis für billiges Rauhfutter fortwährend grösser wird, um unseren Viehstand zu verbessern.

Die diätetisch ungünstige Wirkung der Süsskartoffelstengel erinnert zwar an die Oxalsäurevergiftung des Zuckerrübenkrautes,<sup>1)</sup> die bei der Trocknung desselben durch die Oxydation der Oxalsäure stark geschwächt wird, aber diese Säure wird in den Stengeln nur in Spuren gefunden, während Gerbsäure zu ca. 1% in der Trockensubstanz enthalten ist. Obwohl meine diesbezüglichen Untersuchungen noch nicht abgeschlossen sind, möchte ich hier nur eine kurze Mitteilung machen über einen negativ ausgefallenen Versuch. Ich habe nämlich zwei Kaninchen 5 Tage lang ausschliesslich mit frischem Süsskartoffelkraut gefüttert. Die Tiere nahmen es ohne Zögern und vertrugen diese Nahrung ohne jede gesundheitliche Störung. Danach habe ich noch zwei anderen Kaninchen je 200 g Presssaft aus frischen Stengeln in den hungernden Magen eingespritzt, um eine eventuelle Giftwirkung drastischer hervortreten zu lassen, jedoch habe ich auch dabei gar keine Vergiftungserscheinungen bemerkt.

Die einzige grosse Unbequemlichkeit für die Verwertung der Stengel ist vor allem die zeitraubende Trocknung derselben. Jedenfalls muss man darauf achten, dass man sobald wie möglich die Stengel in die Scheune bringt, nachdem man sie entweder auf dem Felde oder sonst irgendwo im Freien völlig lufttrocken hat werden lassen, damit die Stengel und Blätter nicht durch ungünstige Witterung ausgelaugt werden und verwitern.

Es wäre sehr zweckmässig, wenn man den Stengel möglichst lange an der Luft abwelken liesse und bei ungünstigem Wetter mit Hilfe einer maschinellen Vorrichtung trocknete. In Europa hat man in letzter Zeit

1) E. Pett, Handbuch der tierischen Ernährung und der landw. Futtermittel 1. Bd., S. 99, und E. Honcamp u. T. Katayama, Landw. Versuchsstationen 1907, 67. Bd. S. 443.

mit Erfolg das Dauerfutter, Kartoffel<sup>1)</sup> und Rübenkraut<sup>2)</sup> durch verschiedene Trocknungsapparate getrocknet, jedoch sind solche für vorliegenden Zweck viel zu gross und zu teuer, um sie bei uns einzuführen, da unser landwirtschaftlicher Betrieb sehr klein ist.

Wenn man nun die Werte für den Lufttrockenstengel auf den Stengel im frischen Zustande umrechnet, welcher 12% Trockensubstanz enthält, so erhält man folgende Zahlen:

	Rohprotein %	N-freie Ex- traktstoffe %	Rohfett %	Rohfaser %	Eiweiss %	Stärkewert %
Rohnährstoffe... ..	1.49	5.14	0.41	3.59	1.34	
Verdauliche Nährstoffe...	0.66	3.14	0.23	1.91	0.51	5.0

Der frische Stengel ist ein sehr wässriges, seiner Zusammensetzung nach dem Rübenkraut ähnliches Futter, und er eignet sich nicht zur alleinigen Verfütterung. Der Stengel darf nur in beschränkten Mengen und gleichzeitig in Verbindung mit Stroh, Dürrho oder mit anderem derartigen Trockenfutter gefüttert werden. Trotzdem ist natürlich die Verabreichung der Stengel in frischem Zustande die beste Verwertung, weil damit weder grosse Nährstoffverluste noch anderweitige Unkosten verbunden sind.

## II. UEBER DAS EINSÄUERN VON SÜSSKARTOFFEL- STENGELN IN TONGEFÄSSEN.

Wie ich schon anfangs erwähnte, habe ich in kleinem Massstabe das Einsäuern<sup>3)</sup> der Süsskartoffelstengel versucht, welches im allgemeinen aus Mangel an einem besseren Konservierungsverfahren in Betracht kommt,

1) Landw. Versuchsstationen 1908, 68. Bd. S. 39.

2) Ebenda 1907, 67, Bd. S. 443.

3) Bei den Eiasäuerungsverfahren hat mir Herr Kollege Dr. W. Yamashita freundlichst mündlichen Rat gegeben, dem ich dafür auch an dieser Stelle meinen besten Dank sage.

obwohl in Ensilage gewöhnlich grosse Nährstoffverluste eintreten.<sup>1)</sup> Wenn das Einmieten der Süsskartoffelstengel in Gruben so einfach ausführbar wäre wie bei anderem Sauerfutter, so würde es sicherlich für unsere Landwirte sehr zweckmässig sein. Ich habe zuerst als vorläufigen Versuch ein Tongefäss von ca. 80 l mit kurz geschnittenen Stengeln gefüllt, und wiederum im Jahre 1911 diesen Versuch mit zwei grösseren Gefässen wiederholt.

Die im Gefäss eingestampfte Masse wurde mit einem Holzdeckel bedeckt, auf den noch 2 schwere Steine als Gewicht zum Pressen gelegt wurden. Aber der obere Teil wird sehr leicht nach einigen Tagen dunkelbraun und verdirbt danach so sehr, dass man endlich den Versuch erneuern muss. Dieses Braunwerden kann man jedoch dadurch beschränken, dass man die Stengel einmal auskocht oder im Wasser stehen lässt. Denn es ist höchst wahrscheinlich auf die Oxydation derjenigen Bestandteile im Saft zurückzuführen, die sehr oxydierbar sind, wie z. B. Gerbsäure unter der Mitwirkung von Enzymen. Ich habe daher eine genügende Menge Wasser in das Gefäss gegossen, so dass die Flüssigkeit gerade noch die ganze Masse bedeckte, und dadurch der Luftzutritt möglichst verhindert wurde.

Das Einsäuern ging normal in dieser Weise von statten, und mit dem Sauerfutter wurde erst nach 4 Monaten von Ende März an gefüttert (I. Versuchsreihe, IV. Periode).

Von dem Gefäss, das anfangs 60 kg frischer Stengel (7.7 kg Trockensubstanz) enthielt, wurden vor der Verfütterung ausser 4.6 kg der oberen dunkelbraunen Schicht auch etwa 5 l überfließenden sehr dünnen säuerlichen Saftes entfernt; hiernach waren 64.5 kg Sauerstengel (6.4 kg Trockensubstanz), nämlich etwa 85% der ursprünglichen Trockensubstanz zur Fütterung verwendbar geblieben.

1) *M. Moerker*, Fütterungslehre S. 80; *O. Köhler*, Landw. Versuchsstationen 1880, Bd. 25, S. 447, und „die Ernährung der landw. Nutztiere“ IV. Aufl, S. 240; *B. Schulze*, Centralblatt für Agricultur Chemie 1887, S. 96; *Fr. Tangl u. S. Weiser*, Landw. Versuchsstationen 1911, Bd. 74, S. 263.

Das verfütterte Sauerfutter sah sehr gut aus und hatte angenehm säuerlichen Geruch, aber dasselbe war so wässrig, dass es einen Wassergehalt von 90% zeigte. Die Tiere frassen nicht gern genügende Mengen, nicht allein wegen des Sauergeschmacks und der starken Nässe, sondern auch wegen des grösseren Futtermittelvolumens, besonders konnte Hammel II nicht 1 kg davon vertragen. Ich habe daher in dem vorliegenden Versuche den Tieren nur 900 g Sauerfutter nebst 500 g eines guten Dürrheues verabreicht, dessen Verdaulichkeit gesondert festgestellt worden war.

Die Zusammensetzung der verabreichten Futtermittel, sowie die Verdaulichkeit des Dürrheues waren, auf Trockensubstanz bezogen, folgende :

	Trockensubstanz		Verdauungskoeffizienten des Dürrheues	
	Sauerstengel %	Dürrheu %	Hammel I %	Hammel II %
Organische Substanz...	89.35	86.99	64.5	63.8
Rohprotein ... ..	14.91	10.64	55.9	55.6
N-freie Extraktstoffe ...	39.17	43.87	61.5	61.6
Rohfett ... ..	3.80	1.70	40.8	35.7
Rohfaser ... ..	31.47	30.92	73.1	71.4
Eiweiss... ..	10.45	9.90		

Von den beiden Tieren zum Verzehren vorgelegten Futtermitteln enthielt der Sauerstengel 9.94, das Dürrheu 84.53% Trockensubstanz. Der Kot wurde täglich vom Hammel I mit 234.1 g, vom Hammel II mit 239.1 g in der Trockensubstanz ausgeschieden. Darin war enthalten in Prozenten :

	Hammel I.	Hammel II.
Organische Substanz ... ..	76.76	76.34
Rohprotein ... ..	11.93	12.47
N-freie Extraktstoffe ... ..	41.61	39.44
Rohfett ... ..	2.69	2.62
Rohfaser ... ..	20.53	21.81

Die Verdauungskoeffizienten sind in der folgenden Tabelle zusammengestellt :

	Trocken- substanz g	Organische Substanz g	Roh- protein g	N-freie Ex- traktstoffe g	Rohfett g	Rohfaser g
PERIODE IV.						
Hammel I. (Gewicht 58.5 kg)						
500 g Dür rheu ... ..	422.7	367.7	45.0	185.3	7.2	130.7
900 g Sauerstengel ... ..	89.5	80.0	13.3	35.1	3.4	28.2
Gesamtverzehr :	512.2	447.7	58.3	220.4	10.6	158.9
Im Kot ... ..	234.1	179.7	27.9	97.4	6.3	48.1
Verdaut im Ganzen :	278.1	268.0	30.4	123.0	4.3	110.8
„ vom Dür rheu :	253.4	237.1	25.1	113.9	2.9	95.6
Verdaut von den Sauerstengeln :	24.7	30.9	5.3	9.1	1.4	15.2
Verdaut in Prozenten :	27.6	38.6	39.9	26.0	41.2	54.1
Hammel II. (Gewicht 50.5 kg)						
Gesamtverzehr wie Hammel I.	512.2	447.7	58.3	220.4	10.6	158.9
Im Kot ... ..	239.1	182.5	29.8	94.3	6.3	52.1
Verdaut im Ganzen :	273.1	265.2	28.5	126.1	4.3	106.8
„ vom Dür rheu :	249.1	231.8	24.8	114.3	2.2	90.9
Verdaut von den Sauerstengeln :	24.0	33.4	3.7	11.8	2.1	15.9
Verdaut in Prozenten :	26.9	41.7	27.8	33.6	61.7	56.4
Im Durchschnitt :	27.3	40.2	33.9	29.8	51.5	54.6

Da in diesem Versuchsabschnitte die verfütterte Sauerstengelmengung verhältnismässig zu klein war, sollte unvermeidlich eine ziemlich grössere Fehlergrenze für die Berechnung der Verdauungskoeffizienten gestattet werden, jedoch ist aus den vorstehenden Zahlen leicht ersichtlich, dass die Nährbestandteile des Sauerstengels sehr schlecht verdaulich sind. Wenn man nun die rohe und verdauliche Nährstoffmenge des verfütterten Sauerstengels mit der des ursprünglichen grünen vergleicht, indem man für die Verdauungskoeffizienten des letzteren die für Lufttrockenstengel

in den vorhergehenden Versuchen ermittelten Werte verwendet, so ergeben sich folgende Zahlen in der Trockensubstanz:

	Frischer Stengel		Sauerstengel	
	roh %	verdaulich %	roh %	verdaulich %
Rohprotein ... ..	15.63	7.0	14.91	5.1
N-freie Extraktstoffe ...	40.27	24.6	39.17	11.7
Rohfett ... ..	2.85	1.6	3.80	2.0
Rohfaser ... ..	27.70	15.0	31.47	17.2
Eiweiss ... ..	13.81	5.1	10.45	0.6

Die vorstehenden Zahlen zeigen, dass bei der Einsäuerung die verdaulichen Nährstoffe des Stengels eine starke Einbusse erlitten. Der Sauerstengel war ärmer an Nährstoffen und reicher an Rohfaser als der frische, und ähnelte nunmehr in Bezug auf den Nährwert in der Trockensubstanz dem Reisstroh.

Es kann jedoch die Herstellung eines Sauerstengels von noch etwas besserer Qualität durch die Verbesserung des Einsäuerungsverfahrens als wahrscheinlich erwartet werden. Ich habe daher wiederum Ende Oktober 1911 einen zweiten Versuch angestellt, indem ich die frisch geschnittenen Stengel so stark presste, dass die ganze Masse sich dicht zusammenlegte, wobei kein Aufgusswasser gebraucht wird.

Zwei Tongefässe von etwa 2 Hektoliter Rauminhalt wurden mit geschnittenen Stengeln gefüllt, indem jedesmal etwa 10–20 kg in das Gefäss hinein geworfen und mit den Füßen so lange getreten wurden, bis der obere Teil der Masse durch den ausgepressten Saft etwas nass wurde. Endlich wurde die eingestampfte Masse mit einem dicken Holzdeckel bedeckt und auf diesen viele Ziegelsteine im Gewicht von ca. 300 kg gelegt. Die Masse senkte sich durch das Gewicht nach und nach und andererseits stiegen die dunkelbraunen Säfte so hoch hinauf, dass sie nach 15 Tagen den Holzdeckel bedeckten und dadurch das Gewicht auf ca. 200 kg erleichtert wurde.

Um nun genau zu erkennen, wie gross der Verlust an verdaulichen Nährstoffen beim Einsäuern ist, was bis jetzt in den wenigsten Fällen

bestimmt worden war, habe ich gleichzeitig noch einen Lufttrockenstengel aus demselben grünen Material hergestellt und dessen Nährwert mit dem des Sauerstengels verglichen.

Da ich aber den Lufttrocken- und Sauerstengel in Verbindung mit Heu verabreichen musste, so habe ich zunächst die Verdaulichkeit des Dürrhoes ermittelt.

Die Futterration und Kotmenge sowohl in der Heuperiode wie auch in den anderen beiden waren folgende :

II. Versuchsreihe		Trockensubstanz %	Kot frisch g	Kot trocken g
V. Periode				
Hammel I...	800 g Heu	88.35	691.1	301.5
„ II...	750 g „	„	861.1	276.8
VI. Periode				
Hammel I...	550 g Heu	88.03	796.0	279.8
	1500 Sauerstengel	11.53		
„ II...	450 g Heu	88.03	693.5	219.0
	1200 g Sauerstengel	11.53		
VII. Periode				
Hammel I...	400 g Heu	87.71	601.5	308.0
	400 g Lufttrockenstengel	86.92		
„ II...	350 g Heu	87.71	611.3	273.0
	400 g Lufttrockenstengel	86.92		

Die chemische Analyse ergab folgende, auf Trockensubstanz berechnete Zusammensetzung für das Heu und den Kot :

	Dürrho	Kot	
		Hammel I.	Hammel II.
Organische Substanz ...	87.23	77.59	77.71
Rohprotein ... ..	11.36	11.74	12.17
N-freie Extraktstoffe ...	44.49	39.40	41.87
Rohfett ... ..	2.21	3.07	2.59
Rohfaser ... ..	29.17	23.39	21.07
Eiweiss ... ..	10.81		



Die Verdauungskoeffizienten des Heues sind in der folgenden Tabelle zusammengestellt :

	Trocken-Substanz g	Organische Substanz g	Rohprotein g	N-freie Extraktstoffe g	Rohfett g	Rohfaser g
PERIODE V.						
Hammel I. (Gewicht 41.5 kg)						
500 g Dür rheu ... ..	706.8	616.5	80.3	314.5	15.6	206.2
Im Kot ... ..	301.5	233.9	35.4	118.8	9.3	70.5
Verdaut im ganzen :	405.3	382.6	44.9	195.7	6.3	135.7
Verdaut in Prozenten :	67.4	62.1	55.9	62.2	40.4	65.8
Hammel II. (Gewicht 35.8 kg)						
750 g Dür rheu ... ..	662.6	578.0	75.3	294.8	14.6	193.3
Im Kot ... ..	276.8	215.1	33.7	115.9	7.2	58.3
Verdaut im ganzen :	385.8	362.9	41.6	178.9	7.4	135.0
Verdaut in Prozenten :	58.2	62.8	55.3	60.7	50.7	69.8
In Durchschnitt :	57.8	62.5	55.6	61.5	45.6	67.8

Das eine der beiden Gefässe, das Mitte Oktober 1911 mit 116.7 kg frischen Süsskartoffelstengeln gefüllt wurde, wurde Mitte Februar des folgenden Jahres geöffnet. Man fand in diesem Falle gar keine verdorbene Masse, sondern nur bräunlichgrün gefärbten Sauerstengel in einer obersten dünnen Schicht, darauf gleich den sehr angenehm riechenden hellgrün gefärbten.

Bei der Verabreichung des Sauerstengels muss man aber darauf achten, dass das Futter sofort von den Tieren aufgezehrt wird, wenn es aus dem Gefäss herausgenommen wird, sonst wird es bald braun und geschmacklos. Infolgedessen wurde der Sauerstengel bei jeder Mahlzeit, nämlich 3 mal täglich, wie es beim ersten Versuche geschehen war, frisch herausgenommen und davon 500 g und 400 g zur Fütterung von Hammel I bzw. von Hammel II je nach deren Fresslust, sowie gleichzeitig 40 g

zur Bestimmung des Wassergehaltes abgewogen. Der Trockensubstanzgehalt des verfütterten Sauerstengels schwankte sehr wenig, von 11.22 bis 12.05%, und betrug im Durchschnitt 11.53%.

Die chemische Zusammensetzung der Sauerstengel und des Kotes war in der Trockensubstanz folgende:

	Sauerstengel %	Kot	
		Hammel I. %	Hammel II. %
Organische Substanz ...	87.90	79.52	79.63
Rohprotein ... ..	12.97	13.62	13.32
N-freie Extraktstoffe ...	43.51	39.76	40.49
Rohfett ... ..	4.23	3.31	3.03
Rohfaser ... ..	27.18	22.84	22.79

Die Verdauungskoeffizienten sind in der folgenden Tabelle zusammengestellt:

(Siehe die Tabelle auf S. 59)

Wie ersichtlich, stimmen die Verdauungskoeffizienten für einzelne Bestandteile befriedigend überein und sind viel höher als die der Sauerstengel in dem ersten Versuch. Die Menge der verdaulichen Nährstoffe will ich später zugleich mit den Lufttrockenstengeln besprechen.

Nach Beendigung der Ausnutzungsversuche wurde der im Gefäß noch zurückgebliebene Sauerstengel gewogen, um die Gesamtmenge desselben festzustellen, und ich habe dabei keinen nennenswerten Verlust an Trockensubstanz bei diesem Einsäuern gefunden, wie folgende Ziffern beweisen:

		Trockensubstanz	
		%	kg
Das Gefäß erhielt			
an frischem Stengel...	116.7 kg	11.20	13.07
Aus dem Gefäß genommen			
Sauerstengel ... ..	93.46	11.53	10.77
„ ... ..	18.60	10.70	1.99
Säfte ... ..	3.31	1.21	0.04
		Total	12.80

	Trocken- substanz g	Organische Substanz g	Roh- protein g	N-freie Ex- traktstoffe g	Rohfett g	Rohfaser g
PERIODE VI.						
Hammel I. (Gewicht 40.9 kg)						
550 g Dür rheu ... ..	484.2	422.4	55.0	215.4	10.7	141.2
1500 g Sauerstengel ... ..	173.0	152.1	22.4	75.3	7.3	47.0
Gesamtverzehr :	657.2	574.5	77.4	290.7	18.0	188.2
Im Kot ... ..	279.8	222.5	38.1	111.3	9.3	63.9
Verdaut im ganzen :	377.4	352.0	39.3	179.4	8.7	124.3
Verdaut vom Dür rheu :	277.9	262.3	30.7	134.0	4.3	92.9
Verdaut von den Sauerstengeln :	99.5	89.7	8.6	45.4	4.4	31.4
Verdaut in Prozenten :	57.5	59.0	38.4	60.3	60.3	66.8
Hammel II. (Gewicht 35.1 kg)						
450 g Dür rheu ... ..	396.1	345.5	45.0	176.2	8.8	115.5
1200 g Sauerstengel ... ..	138.4	121.1	18.0	60.2	5.9	37.6
Gesamtverzehr :	534.5	467.2	63.0	236.4	14.7	153.1
Im Kot ... ..	219.0	174.4	29.2	88.7	6.6	49.9
Verdaut im ganzen :	315.5	292.8	33.8	147.7	8.1	103.2
Verdaut vom Dür rheu :	230.5	217.0	24.9	107.0	4.5	80.6
Verdaut von den Sauerstengeln :	85.0	75.8	8.9	40.7	3.6	22.6
Verdaut in Prozenten :	61.4	62.3	49.4	67.6	61.0	60.1
Im Durchschnitt :	59.5	60.7	43.9	64.0	60.7	63.5

Der Lufttrockenstengel wurde, auf Matten vor Wind und Regen geschützt, sehr sorgfältig hergestellt. Da das Wetter aber am Anfang der Trocknung oftmals ungünstig war, so dauerte sie etwa 2 Wochen. Von 178.7 kg frischen Süßkartoffelstengeln wurden 22.83 kg Lufttrockenstengel mit 86,92% Trockensubstanz erhalten.

Die chemische Zusammensetzung der Lufttrockenstengel und des Kotes waren in der Trockensubstanz folgende :

	Lufttrockenstengel	Kot	
		Hammel I.	Hammel II.
		%	%
Organische Substanz ...	87.96	82.22	81.63
Rohprotein ...	12.62	14.46	14.41
N-freie Extraktstoffe ...	44.86	39.21	40.11
Rohfett ...	3.15	3.63	3.19
Rohfaser ...	27.34	24.91	23.93
Eweiss ...	10.79	24.01	23.93

Die Verdauungskoeffizienten sind in der folgenden Tabelle zusammengestellt :

(Siehe die Tabelle auf S. 61)

Dieser Lufttrockenstengel ist der Zusammensetzung und den verdaulichen Nährstoffmengen nach dem des vorhergehenden Versuchsabschnittes sehr ähnlich.

Wenn man nun die Nährstoffmenge der Sauerstengel mit der der Lufttrockenstengel vergleicht, so ergeben sich folgende prozentische Zahlen in der Trockensubstanz :

	Lufttrockenstengel			Sauerstengel		
	Roh-nährstoffe	Verdauungs-koeffizienten	Verdauliche Nährstoffe	Roh-nährstoffe	Verdauungs-koeffizienten	Verdauliche Nährstoffe
Organische Substanz ...	87.96	57.4	50.5	87.90	60.7	53.4
Rohprotein ...	12.62	42.4	5.4	12.97	43.9	5.7
N-freie Extraktstoffe ...	44.86	62.3	27.9	43.51	64.0	27.7
Rohfett ...	3.16	45.9	1.4	4.23	60.7	2.6
Rohfaser ...	27.34	58.0	15.9	27.18	63.5	17.3
Eiweiss ...	11.79		4.6	10.92		3.6
Amide ...	0.83			2.05		

Aus den vorstehenden Zahlen erkennt man, dass eine geringe Verminderung der stickstofffreien Extraktstoffe in der Zusammensetzung bei der Einsäuerung entstand, und ein Teil des Eiweisses in minderwertige, nicht proteinartige Substanz übergeführt wurde. Diesem Verlust gegenüber sieht man eine Vermehrung der verdaulichen Mengen von Rohfett und Rohfaser im Sauerstengel. Die Vermehrung des Rohfettes ist bekanntlich eine Folge davon, dass andere, nicht zu den Fetten gehörende

	Trocken- substanz g	Organische Substanz g	Rob- protein g	N-freie Ex- traktstoffe g	Rohfett g	Rohfaser g
PERIODE VII.						
Hammel I. (Gewicht 40.6 kg)						
400 g Dür rheu ... ..	350.8	306.0	39.9	156.1	7.8	102.3
400 g Trockenstengel ... ..	347.7	305.8	43.9	156.0	11.0	95.1
Gesamtverzehr :	698.5	611.8	83.8	312.1	18.8	197.4
Im Kot ... ..	308.0	253.2	44.5	120.8	11.2	76.7
Verdaut im ganzen :	390.5	358.6	39.3	191.3	7.6	120.7
Verdaut vom Dür rheu :	201.4	190.0	22.3	97.1	3.2	67.3
Verdaut von den Trockenstengeln :	189.1	168.6	17.0	94.2	4.4	53.4
Verdaut in Prozenten :	54.4	55.1	38.7	60.4	40.0	56.2
Hammel II. (Gewicht 35.5 kg)						
350 g Dür rheu ... ..	307.0	267.8	34.9	136.6	6.8	89.6
400 g Trockenstengel ... ..	347.7	305.8	43.9	156.0	11.0	95.1
Gesamtverzehr :	654.7	573.6	78.8	292.6	17.8	184.7
Im Kot ... ..	273.0	222.8	39.3	109.5	8.7	65.3
Verdaut im ganzen :	381.7	350.8	39.5	183.1	9.1	119.4
Verdaut vom Dür rheu :	178.7	168.2	19.3	82.9	3.4	62.5
Verdaut von den Trockenstengeln :	203.0	182.6	20.2	100.2	5.7	56.9
Verdaut in Prozenten :	58.4	59.7	46.0	64.2	51.8	59.8
In Durchschnitt :	56.4	57.4	42.4	62.3	45.9	58.0

Stoffe, wie z. B. Milchsäure und Buttersäure, die hauptsächlich aus Kohlenhydraten gebildet werden, bei der Analyse in die ätherische Fettlösung übergehen. Die Menge der verdaulichen stickstofffreien Extraktstoffe des Sauerstengels, von denen ein nicht unbedeutender Teil aus minderwertigen Säuren entstanden sein mag, war aber ebenso gross wie die im Lufttrockenstengel.

Jedenfalls ist ersichtlich, dass der Nährwert des Süsskartoffelstengels durch das Einsäuern gar keinen bedeutenden Einfluss erlitten hat.

Solche Resultate wurden nur bei Sauermais in den Vereinigten Staaten

beobachtet, während in anderen Fällen immer ein erheblicher Verlust an Nährstoffen in mehreren Einsäuerungsversuchen erfahren wurde. Nach *W. A. Johnson* und *F. H. Hall*<sup>1)</sup> wies der Sauermais in 8 Versuchen unter 10, welche sie zusammenstellten, einen etwas höheren Verdauungskoeffizienten als getrocknetes Futter auf. *Fr. Tangl* und *S. Weiser*<sup>2)</sup> versicherten auch nach ihren Versuchen in Ungarn, dass der Nährwert des Maisstrohes durch die Konservierung in Silos nur in geringem Masse vermindert, während die Bekömmlichkeit gesteigert wird.

Die günstigen Resultate des Sauerstengels dieser Versuche sind wahrscheinlich darauf zurückzuführen, dass das Einmieten nicht nur in einem verbesserten Verfahren ausgearbeitet, sondern auch, dass das Einmieten nicht über 3 Monate in der kältesten Zeit dauerte. Andererseits konnte auch möglicherweise irgendein Verlust an Nährstoffen bei der Herstellung des Lufttrockenstengels auftreten, welcher Prozess infolge der mangelnden Trockenheit über 10 Tage dauerte, durch die Atmung der noch lebenden Pflanzenzellen und durch die Tätigkeit der anhaftenden Mikroorganismen.<sup>3)</sup>

Das Einsäuern in dem zweiten Gefäss ging ebenso gut wie in dem ersten von statten, und der Sauerstengel wurde Mitte März an einige Kühe verfüttert, die in einer Milchwirtschaft in der Nähe unserer Versuchsstation gehalten wurden. Sie frassen sehr gern und zögerten sogar nicht zwei bis drei Tage lang ausser dem Gefäss gehaltenes und dadurch etwas dunkel gewordenes Futter zu nehmen. Man bemerkte dabei keine ungünstige Wirkung des Sauerstengels auf die Qualität der Milch.

Obzwar diese Untersuchungen in zu kleinem Massstabe geführt wurden, zeigen die Ergebnisse doch deutlich, dass das Einsäuern für die Verwertung des Süsskartoffelstengels als Futtermittel sehr gute Dienste leisten kann. Es wurde daher nun sehr wünschenswert, das Einmieten in den landwirtschaftlichen Zwecken entsprechenden Gruben zu versuchen, worüber ich endlich im Winter 1912 einen Versuch angestellt habe.

1) *The Digestibility of American Feeding Stuffs*, 1900; p. 95-97.

2) *Landw. Versuchsstationen*, 1911, Bd. 74, S. 323.

3) *O. Kellner*, Die Ernährung der landw. Nutztiere, 4 Auflage, S. 222; *A. Morgen*, *C. Berger* u. *E. Westhauser*, *landw. Versuchsstationen* 1911, Bd. 75, S. 321-348.

### III. UBER DAS EINMIETEN VON SÜSSKARTOFFEL- STENGELN IN GRUBEN.

Eine tiefe cylinderförmige Grube wurde in unserer Versuchsstation ausgegraben. Da die Oberschicht der Grubenwand etwa 0.6 m tief aus Humus enthaltendem leichten Lehm besteht, die untere Schicht hingegen aus Tonerde (Diluvium), so wurde die innere Seite gänzlich so dick und fest mit steifem Ton bekleidet, dass weder Pflanzensäfte noch Bodenwasser leicht die Wand durchdringen konnten. Der Durchmesser des inneren Raumes betrug im Durchschnitt ca. 1.26 m von der Mündung bis zu ca. 1.20 m Tiefe. Die Bodenfläche in 1.80 m Tiefe mass 1.19 m im Durchmesser. Das Fassungsvermögen war über 22 Hektoliter.

Das Einbringen der Süsskartoffelstengel in die Grube begann am 28. Oktober. Am ersten Tage wurden 620 kg, am nächsten 834 kg kurz geschnittener Stengel eingefüllt, indem die Masse von drei Arbeitern stets mit den Füßen fest getreten wurde. Am dritten Tage, am 1. November, wurde die Grube so weit mit Stengeln gefüllt, dass dieselben die Bodenfläche noch etwa 0,60 m überragten. Die eingestampfte Masse betrug genau 1912 kg und dieselbe wurde schliesslich mit einem Holzdeckel bedeckt, der durch mit Kieselsteinen gefüllte Kisten im Gewicht von ca. 600 kg beschwert wurde. Über der Grube wurde noch ein Dach aus Stroh hergestellt, um den Eintritt des Regenwassers zu verhindern.

Während des Füllens der Grube wurden gleichzeitig noch 31 kg Lufttrockenstengel aus 248 kg des gleichen grünen Materials hergestellt, um deren Nährwert mit dem des Sauerstengels zu vergleichen.

Die Masse in der Grube zog sich nach und nach zusammen und senkte sich so weit, dass der Deckel schon nach acht Tagen der Erdfäche gerade eben war und endlich nach drei ein halb Monaten ca. 0.50 m tiefer als der Rand der Grube lag.

Die Grube wurde Mitte März des folgenden Jahres geöffnet. Unter der obersten sehr dünnen Schicht erschienen gleich die sehr angenehm riechenden Stengel. Jedoch war eine kleine Masse im oberen Teil dunkelbraun und verschimmelt, welche sich im Zwischenraum zwischen dem

beschwerten Deckel und der Wandfläche der Grube befand und beswegen nicht genug komprimiert war. Sowohl diese verdorbenen als auch die nur durch die Tonerde der Wandfläche beschmutzten Stengel wurden beiseite gelegt und gewogen. In dieser Weise wurden die Mengen des unbrauchbaren und guterhaltenen Materials genau bestimmt.

Die Menge der in die Grube eingeführten frischen Stengel betrug 1912 kg mit einem Wassergehalt von 88,80%, also 214 kg Trockensubstanz. Aus der Grube wurden insgesamt 1365 kg geholt, wovon 1280 kg gutes Futter mit Trockensubstanz von 15,3% und 86 kg unverwendbares mit 17,5% Trockensubstanz war. Das macht 6% des Sauerfutters aus, was allerdings nicht als grösserer Verlust zu betrachten ist.

Um für die Ausnützungsversuche ein gutes Durchschnittsmaterial zu gewinnen, wurde Sauerfutter von verschiedenen Stellen der Grube entnommen und sofort in einem Krug von zwei Hektoliter Inhalt stark eingestampft. Der Krug wurde während der Versuche an einem kalten Platz stehen gelassen, indem dabei eine starke Pressung angewandt wurde.

Die Anordnung der Versuche war dieselbe wie bei den vorhergehenden. Hammel I. frass mit guter Fresslust täglich 2 kg Sauerfutter aus, während Hammel II. dasselbe anfangs sehr hartnäckig verweigerte, bald jedoch verzehrte er die ganze Versuchsdauer hindurch 1,7 kg ohne Rest.

Die Futtermenge und Kotmenge in drei Versuchsperioden mit Heu- und den beiden Stengelfuttern ergaben folgende Zahlen:

### III. Versuchsreihe

		Trockensubstanz	Kot frisch	Kot trocken
		%	g	g
VIII. Periode				
Hammel I.	800 g Dür rheu	88.84	773.7	326.3
„ II.	„	„		325.5
IX. Periode				
Hammel I.	300 g Dür rheu	89.85	550.1	277.6
	2000 „ Sauerstengel	15.01		
„ II.	300 „ Dür rheu	89.85	459.3	241.1
	1700 „ Sauerstengel	15.01		



		Trockensubstanz	Kot frisch	Kot trocken
		%	g	g
X. Periode				
Hammel I.	400 g Dür rheu	89.85	776.7	333.8
	400 g Luft trocken stengel	87.85		
„ II.	dieselben wie Hammel I.		730.6	324.3

Die chemische Untersuchung der drei Futtermittel sowie der Kotproben ergab folgende auf Trockensubstanz berechnete Werte :

	Organ. Substanz	Rohprotein	N-freie Extraktstoffe	Rohfett	Rohfaser	Eiweiss
Dür rheu ... ..	87.50	10.02	46.99	2.17	28.32	9.53
Sauerstengel ... ..	88.11	11.81	42.98	5.03	28.29	9.80
Luft trocken stengel ...	88.11	11.22	43.69	3.90	29.30	10.38
Kot.						
Periode VIII.						
Hammel I. ... ..	78.83	10.17	42.01	2.40	24.16	
„ II. ... ..	77.55	9.84	41.26	2.43	24.02	
Periode IX.						
Hammel I. ... ..	80.76	12.07	39.38	2.93	26.37	
„ II. ... ..	81.06	12.17	39.22	2.87	26.37	
Periode X.						
Hammel I. ... ..	81.11	12.08	40.43	2.95	25.65	
„ II. ... ..	81.10	11.86	41.50	2.03	24.80	

Die Verdauungskoeffizienten der drei Futtermittel sind in der folgenden Tabelle zusammengestellt :

(Siehe die Tabelle auf S.66 u.67)

Die Versuche gingen durchweg befriedigend glatt, indem die Verdauungskoeffizienten für die einzelnen Bestandteile in allen Versuchsabschnitten sehr gut übereinstimmten.

	Trocken-Substanz g	Organische Substanz g	Roh- protein g	N-freie Ex- traktstoffe g	Rohfett g	Rohfaser g
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## PERIODE VIII.

## Hammel I. (Gewicht 43.5 kg)

300 g Dürreheu ... ..	710.7	621.9	71.2	334.0	15.4	201.3
Im Kot ... ..	326.3	257.2	33.2	137.1	7.8	78.8
Verdaut im Ganzen :	384.4	364.7	38.0	196.9	7.6	122.5
„ in Prozenten :	54.1	58.6	53.4	59.0	49.4	60.9

## Hammel II. (Gewicht 34.5 kg)

Gesamtverzehr wie Hammel I.	710.7	621.9	71.2	334.0	15.4	201.3
Im Kot ... ..	325.5	252.4	32.0	134.3	7.9	78.2
Verdaut im Ganzen :	385.2	369.5	39.2	199.7	7.5	123.1
„ in Prozenten :	54.2	59.4	55.1	59.8	48.7	61.2
Im Durchschnitt :	54.2	59.0	54.3	59.4	49.1	61.1

## PERIODE IX.

## Hammel I. (Gewicht 43.5 kg)

300 g Dürreheu ... ..	269.6	235.9	27.0	126.7	5.9	76.4
2000 g Sauerstengel ... ..	300.2	264.5	35.5	129.0	15.1	84.9
Gesamtverzehr :	569.8	500.4	62.5	255.7	21.0	161.3
Im Kot ... ..	277.6	224.2	33.5	109.3	8.1	73.2
Verdaut im Ganzen :	292.2	276.2	29.0	146.4	12.9	88.1
„ von Dürreheu :	145.9	138.2	14.4	74.8	2.9	46.5
Verdaut von den Sauerstengeln :	146.3	138.0	14.6	71.6	10.0	41.6
Verdaut in Prozenten :	48.7	52.2	41.1	55.5	66.2	49.0

	Trocken-Substanz g	Organische Substanz g	Roh- protein g	N-freie Ex- traktstoffe g	Rohfett g	Rohfaser g
Hammel II. (Gewicht 33.0 kg)						
300 g Dürrheu ... ..	269.6	235.9	23.0	126.7	5.9	76.4
1700 g Sauerstengel...	255.2	224.9	30.1	109.7	12.8	72.2
Gesamtverzehr:	524.8	460.8	57.1	236.4	18.7	148.6
Im Kot ... ..	241.1	195.4	29.3	94.6	6.9	64.6
Verdaut im Ganzen :	283.7	265.4	27.8	141.8	11.8	84.0
„ vom Dürrheu :	146.1	140.1	14.9	75.8	2.9	46.8
Verdaut von den Sauerstengeln :	137.6	125.3	12.9	66.0	8.9	37.2
Verdaut in Prozenten :	53.9	55.7	42.9	60.2	69.5	51.5
Im Durchschnitt :	51.3	54.0	42.0	57.9	67.9	50.3

## PERIODE X.

Hammel I. (Gewicht 43.0 kg)						
400 g Dürrheu ... ..	359.4	314.5	36.0	168.9	8.0	101.8
400 g Lufttrockenstengel ... ..	351.4	309.6	39.4	153.6	13.7	103.0
Gesamtverzehr :	710.8	624.1	75.4	322.4	21.7	204.8
Im Kot ... ..	333.8	270.7	40.3	135.0	9.8	85.6
Verdaut im Ganzen :	377.0	353.4	35.1	187.4	11.9	119.2
„ vom Dürrheu :	194.4	184.3	19.2	99.7	4.0	62.0
Verdaut von den Lufttrocken- stengeln :	182.6	169.1	15.9	87.7	7.9	57.2
Verdaut in Prozenten :	52.0	54.6	40.4	57.1	57.7	55.5

Hammel II. (Gewicht 35.0 kg)						
Gesamtverzehr wie Hammel I.	710.8	624.1	75.4	322.4	21.7	204.8
Im Kot ... ..	324.3	263.0	38.5	134.9	9.5	80.4
Verdaut im Ganzen :	386.5	361.1	36.9	187.8	12.2	124.4
„ vom Dürrheu :	194.8	186.8	19.8	101.0	3.9	62.3
Verdaut von den Lufttrocken- stengeln :	191.7	174.3	17.1	86.8	8.3	62.1
Verdaut in Prozenten :	54.6	56.3	43.4	56.5	60.6	60.3
Im Durchschnitt :	53.3	55.5	41.9	56.8	59.2	57.9

Um bei der Vergleichung der zwei Sorten Stengel einen besseren Überblick gewinnen zu können, habe ich in nachstehender Tabelle einfach die rohe und verdauliche Nährstoffmenge in der Trockensubstanz zusammengestellt:

	Lufttrockenstengel			Sauerstengel		
	Roh- nährstoffe %	Verdauungs- koeff. %	Verd. Nährstoffe %	Roh- nährstoffe %	Verdauungs- koeff. %	Verd. Nährstoffe %
Organische Substanz.	88.11	55.5	48.80	88.11	54.0	47.6
Rohprotein ... ..	11.22	41.9	4.7	11.81	42.0	5.0
N-freie Extraktstoffe.	43.69	56.8	24.8	42.98	57.9	24.9
Rohfett ... ..	3.90	59.2	2.3	5.03	67.9	3.4
Rohfaser ... ..	28.30	57.9	17.0	28.20	50.3	14.2
Eiweiss ... ..	10.38		3.9	9.80		3.0
Amide ... ..	0.84			2.01		

Die vorstehenden Zahlen zeigen, dass bei der Einsäuerung in der Erdgrube die verdaulichen Nährstoffe der Stengel keine starke Einbusse erlitten haben.

Ich fasse nun die Versuchsergebnisse folgendermassen zusammen:

Die Stengel und Blätter der Süsskartoffel sind im frischen Zustande ein sehr wässriges, seiner Zusammensetzung nach den Rübenblättern ähnliches Futter, das aber nicht Oxalsäure, sondern etwas Gerbsäure enthält.

Der Lufttrockenstengel, der besonders seines feinen Aromas wegen von den Tieren gierig aufgezehrt wird, kommt seinem Nährwert nach einem Dürrehu von mittlerer Güte beinah gleich,—wenigstens muss er unter unseren japanischen Rauhfutterarten als ein solches von sehr guter Sorte bezeichnet werden. Es ist daher sehr wünschenswert, die Stengel nicht als blossen Ballast zu betrachten, sondern als gutes Rauhfutter möglichst viel in frischem und lufttrockenem Zustande zu verwerten.

Wenn die Herstellung der Lufttrockenstengel dem Landwirt wegen der ungünstigen klimatischen Verhältnisse oder wegen der zeitraubenden Beanspruchung eines grösseren Platzes unmöglich ist, so ist es ratsam, die Stengel einzumieten.

Die Sauerstengel können einfach sowohl in kleinen Gefässen als auch in grösseren Gruben hergestellt werden, indem man dabei durch starke Pressung aus der eingestampften Masse die Luft möglichst gut ausschliessen muss.

Bei der Einsäuerung ist in beiden Versuchen kein bedeutender Verlust an Nährstoffen der Stengel entstanden, trotzdem ein Teil des Eiweisses in nicht proteinartige Substanz übergeführt wurde.

Wenn die Durchschnittszahlen für die Nährstoffmenge in frischen und lufttrockenen Stengeln aus den dreijährigen Versuchen, sowie dieselben für Sauerstengel aus den zwei letzten Versuchen berechnet werden, so ergeben sich folgende Zahlen:—

	Frische Stengel <sup>1)</sup>		Lufttrockenstengel		Sauerstengel	
	Roh-nährstoffe %	Verdaul. Nährstoffe %	Roh-nährstoffe %	Verdaul. Nährstoffe %	Roh-nährstoffe %	Verdaul. Nährstoffe %
Wasser ... ..	88.5		12.5		87.0	
Asche ... ..	1.4		10.3		1.6	
Rohprotein ... ..	1.4	0.6	10.6	4.6	1.6	0.7
N-freie Extraktstoffe.	5.0	3.0	38.3	23.0	5.6	3.4
Rohfett ... ..	0.4	0.2	3.1	1.7	0.6	0.4
Rohfaser ... ..	3.3	1.9	25.2	14.4	3.6	2.1
Eiweiss ... ..	1.3	0.5	9.7	3.8	1.4	0.4
Stärkewert ... ..		4.8		29.6		5.7 <sup>2)</sup>

1) Bei der Berechnung der Nährstoffmengen von frischen Stengeln wurden die für Lufttrockenstengel ermittelten Werte verwendet.

2) Der Stärkewert des Sauerstengels war nach der für Grünfutter angegebenen Weise berechnet.

## ANHANG.

## I. VERSUCHSREIHE.

## Periode I. Grundfutter.

Datum :	Hammel I.			Hammel II.		
	Tränkwasser- konsum ccm	Kot frisch g	Kot trocken g	Tränkwasser- konsum ccm	Kot frisch g	Kot trocken g
1908 5. November	1240	510.0	284.6	1420	596.0	283.0
6. „	1100	483.0	253.8	1360	702.0	320.6
7. „	1520	495.0	268.6	1740	603.0	303.0
8. „	1340	542.0	291.7	1120	619.0	296.5
9. „	600	555.0	293.7	1220	624.0	293.3
10. „	1100	531.0	284.6	1340	614.0	293.2
11. „	1040	585.0	300.7	1340	653.5	301.4
12. „	1420	487.0	255.9	1680	671.0	317.1
13. „	610	480.0	262.6	1210	588.5	285.0
14. „	1300	538.0	288.9	1160	584.0	288.9
Im Mittel :	1127	520.6	278.5	1359	625.5	298.2

## Periode II. Lufttrockenstengel.

1908 21. November	790	486.0	266.5	1260	546.0	272.3
22. „	380	490.0	267.9	1090	630.0	311.6
23. „	600	558.0	309.3	1140	629.0	318.6
24. „	1200	613.0	326.3	1000	675.0	323.9
25. „	1030	528.0	293.5	1250	637.0	305.4
26. „	1370	520.5	283.1	1740	569.8	286.3
27. „	940	610.0	335.4	1140	577.0	300.4
28. „	400	453.0	246.2	680	562.0	296.4
29. „	1000	545.0	305.2	1130	470.0	266.6
30. „	1180	552.0	297.9	1700	500.0	290.6
Im Mittel :	889	535.6	293.1	1213	585.6	297.2

## Periode III. Getrocknete Stengel.

Datum :	Hammel I.			Hammel II.		
	Tränkwasser- konsum ccm	Kot frisch g	Kot trocken g	Tränkwasser- konsum ccm	Kot frisch g	Kot trocken g
1908 7. December	1200	545.0	295.9	1260	537.0	286.2
8. „	1800	547.0	284.9	1600	557.0	281.5
9. „	100	565.0	298.3	300	617.5	328.2
10. „	380	590.0	286.3	1550	582.0	297.9
11. „	1020	643.0	308.9	960	615.0	308.8
12. „	1100	597.0	300.0	1060	519.0	267.9
13. „	680	606.5	308.2	1080	544.0	284.3
14. „	980	535.0	273.2	830	620.0	317.3
15. „	1320	510.0	256.3	1540	560.0	282.1
16. „	1590	500.0	270.4	1600	581.0	290.6
Im Mittel	1017	563.9	288.2	1178	573.3	294.5

## Periode IV. Sauerstengel.

1909 23. März	20	398.5	211.4	100	400.0	211.6
24. „	680	459.0	245.3	178	439.5	237.6
25. „	645	486.0	243.5	1120	473.5	226.3
26. „	50	416.0	208.3	780	511.0	240.6
27. „	810	463.0	231.5	1430	469.0	227.3
28. „	20	525.0	268.7	1300	523.0	251.1
29. „	330	433.5	227.8	1280	498.0	245.1
30. „	10	430.0	230.5	1490	508.5	254.2
31. „	280	413.0	222.0	990	513.0	261.9
1. April	210	471.0	251.7	870	458.0	235.2
Im Mittel	306	449.5	234.1	954	479.4	239.1

## II. VERSUCHSREIHE.

## Periode V. Grundfutter.

Datum :	Hammel I.			Hammel II.		
	Tränkwasser- konsum ccm	Kot frisch g	Kot trocken g	Tränkwasser- konsum ccm	Kot frisch g	Kot trocken g
1. 1912 Februar	1200	604.0	265.8	1240	809.0	269.0
2. „	1100	664.5	298.1	1350	860.0	275.8
3. „	1820	664.5	294.9	1740	883.5	287.4
4. „	1340	714.0	317.5	600	961.0	295.9
5. „	650	645.5	286.3	1130	900.0	274.7
6. „	1120	710.5	327.3	1320	842.0	265.3
7. „	1030	674.0	297.8	1680	728.5	248.8
8. „	1420	735.0	309.4	840	839.0	271.3
9. „	460	734.0	310.6	1160	848.0	279.3
10. „	1300	765.0	306.9	1050	940.0	300.3
Im Mittel :	1144	691.1	301.5	1211	861.1	276.8

## Periode VI. Sauerstengel.

24. 1912 Februar	20	1151.0	326.3	100	923.0	243.5
25. „	680	1040.0	317.5	178	962.2	244.1
26. „	645	823.0	269.2	1120	872.0	230.6
27. „	50	825.0	262.3	780	690.0	203.7
28. „	810	825.0	268.4	830	568.2	198.5
29. „	20	713.3	253.6	1300	674.0	218.4
1. März	330	706.0	264.8	380	628.5	217.6
2. „	10	623.0	263.1	890	560.0	212.0
3. „	280	624.0	285.5	690	497.0	205.8
4. „	210	630.0	287.0	870	560.0	216.2
Im Mittel	306	796.0	279.8	714	693.5	219.0



## Periode VII. Lufttrockenstengel.

Datum :	Hammel I.			Hammel II.		
	Tränkwasser- konsum ccm	Kot frisch g	Kot trocken g	Tränkwasser- konsum ccm	Kot frisch g	Kot trocken g
11. 1912 März	1060	619.0	319.6	1130	662.0	279.5
12. „	1380	621.0	311.5	1050	690.0	284.5
13. „	1430	570.0	283.8	1760	720.0	285.9
14. „	930	605.0	309.5	770	652.0	272.5
15. „	680	640.6	326.6	1120	635.0	265.2
16. „	380	610.0	306.2	1080	626.0	268.4
17. „	910	565.0	292.3	1250	550.0	260.8
18. „	1030	560.0	290.8	1080	535.0	268.3
19. „	630	594.0	313.1	990	532.0	265.0
20. „	820	630.0	327.0	1320	536.0	280.0
Im Mittel :	925	601.5	308.0	1155	611.3	273.0

## III. VERSUCHSREIHE.

## Periode VIII. Grundfutter.

Datum :	Hammel I :			Hammel II :		
	Tränkwasser- konsum ccm	Kot frisch g	Kot trocken g	Tränkwasser- konsum ccm	Kot frisch g	Kot trocken g
24. 1913 Februar	950	605.5	281.2	760	710.0	303.0
25. „	1420	700.0	329.0	1080	714.0	295.9
26. „	1190	682.5	298.8	1430	784.5	341.5
27. „	1440	750.0	338.7	950	765.0	328.1
28. „	1100	714.0	314.0	1240	695.5	306.1
1. März	1650	752.0	333.8	1400	754.0	328.3
2. „	1300	855.5	378.9	830	784.0	336.6
3. „	1160	767.0	331.9	950	900.5	351.7
4. „	1430	699.0	322.2	1420	829.5	330.1
5. „	1100	809.5	334.1	1230	800.5	333.9
Im Mittel :	1274	733.5	326.3	1129	774.2	325.5

## Periode IX. Sauerstengel

Datum :	Hammel I.			Hammel II.		
	Tränkwasser- konsum ccm	Kot frisch g	Kot trocken g	Tränkwasser- konsum ccm	Kot frisch g	Kot trocken g
13. 1913 März	100	618.0	305.7	600	482.5	249.3
14. „	50	530.0	280.8	60	410.6	235.1
15. „	80	519.0	270.3	510	483.0	249.0
16. „	20	516.0	264.8	580	476.0	235.3
17. „	50	550.5	281.1	20	490.0	245.1
18. „	0	578.0	289.2	400	485.5	244.7
19. „	30	540.0	265.0	860	508.0	247.2
20. „	50	550.5	260.0	130	438.5	230.9
21. „	55	555.0	283.0	450	514.0	240.1
22. „	40	544.0	276.3	340	470.0	234.0
Im Mittel :	48	550.1	277.6	395	475.8	241.1

## Periode X. Lufttrockenstengel

30. 1913 März	1730	744.5	315.0	1240	676.5	311.4
31. „	1900	783.5	332.6	1460	665.0	326.0
1. April	2260	742.0	306.5	1950	665.0	330.6
2. „	1660	735.0	335.1	1950	638.0	322.4
3. „	1780	839.5	362.0	1620	663.5	328.1
4. „	1995	771.0	346.9	1997	679.0	303.1
5. „	2040	792.5	334.9	1660	681.0	338.3
6. „	2520	795.0	345.6	1870	658.0	309.8
7. „	1950	770.5	313.8	1900	718.0	335.9
8. „	1730	794.0	345.9	1640	662.5	337.8
Im Mittel :	1956	776.8	333.8	1733	670.7	324.3

# Investigations on the Manufacture of Tea.

By

S. SAWAMURA.

## I. EFFECT OF STEAMING ON THE ACTIVITY OF THE ENZYMES OF TEA LEAVES.

In green tea leaves there are abundant oxydizing enzymes present. Wherefore *Mann* in India holds the opinion that oxydizing enzyme is one of the factors which determine the quality of tea. In the manufacture of green tea, however, the oxydizing enzyme of tea leaves is killed by steaming, in order to retain the green color of tea leaves, which would be destroyed by the activity of the enzymes. The author<sup>1)</sup> found in another investigation that the formation of a special aroma of manufactured tea, which takes place usually during the rolling of tea leaves, is due to the action of a certain enzyme on a certain compound of tea leaf. Hence if steaming kills all the enzymes of tea leaves the production of aroma may be more or less hindered.

In 1909 I tried to discover whether all the enzymes of the leaves lose activity by steaming in the usual manner. In these trials green leaves were steamed in the customary way, for 30 seconds, 50 seconds and one minute respectively, and the steamed as well as the unsteamed leaves were crushed and extracted with 40% alcohol. The extracts were precipitated with ether-alcohol and filtered. The precipitates were washed with alcohol and again dissolved in water. The solution gave no reaction with  $\text{Fe}_2\text{Cl}_6$ , proving the absence of tannin. Oxydising

1) Bulletin of Imp. Centr. Agric. Exp-Station. Vol. I., No. 2, p. 151.

enzymes were tested with guajak tincture, and guajacol and  $H_2O_2$ , by which the solution obtained from unsteamed leaves showed the characteristic reaction, while the steamed did not. Steaming for 30 seconds killed the oxydizing enzymes completely. In another trial tea leaves steamed for 20 seconds were tested for the presence of oxydases, and a faint reaction was observed. From these facts we know that the oxydizing enzymes of tea leaves lose activity when they are steamed even only for 30 seconds.

I tried then to see whether enzymes other than oxydase lose activity by steaming for a short time. Preliminarily I detected diastase in tea leaf by the following method. Green tea leaves were crushed in a mortar and extracted with 40% alcohol. To the extract ether-alcohol was added, and the precipitate thereby formed was washed and again dissolved in water. In this solution tannin was removed by hide powder, and putrefaction was prevented by the addition of thymol. It was filtered, and to the filtrate which gave no reaction with  $Fe_2Cl_6$  and did not reduce Fehling's solution, some boiled starch and thymol were added, and the solution, after having been kept at  $40^\circ C$  for 4 days, reduced Fehling's solution considerably. We confirmed by this trial that diastase of tea leaves can be detected in this manner.

The tea leaves steamed for 30 seconds, after which the oxydases were completely killed, reduced also Fehling's solution when treated in the same manner. Hence we know that oxydases are much more sensitive than other enzymes such as diastase, and it is highly probable that some enzymatic actions take place in the first stage of rolling tea leaves, and the production of a fine aroma is due to them. In practice, therefore, the steaming of tea leaves must be so regulated as to kill only the oxydizing enzymes but not to hurt other enzymes.

## II. EFFECT OF ROLLING ON THE SOLUBILITY OF TEA.

Whether the object of rolling tea leaves in the manufacture of green tea is to give tea a fine shape or to press out the juice in order to

accelerate the dessication of the leaves, or to break the cells in order to increase solubility, is as far as I know, not yet decided. According to the investigation of *Dr. Kozai*<sup>1)</sup> the solubility of green tea was little increased by the manipulation, but *Rombe* and *Roman's* experiment<sup>2)</sup> showed on the contrary the decrease of soluble tannin and their.

To settle this question I made an experiment in 1905, in which fresh tea leaves, picked at a sheltered tea garden, were divided into three parts and one of them was steamed and dried without rolling, which served as control, the second part was prepared into green tea (*Gyokuro*), and the third part into *Tencha*, which is usually prepared without rolling the leaves. The infusion of these three kinds of tea was found to be as follows:—

	Control	<i>Tencha</i>	<i>Gyokuro</i>
Colour	light	deeper	deepest
Flavour	weak	stronger	strongest
Taste	faint	good	best

The reaction of the infusion with  $Fe_2Cl_6$  was not the same in the three kinds; that of *Gyokuro* produced a deep black colour, while control and *Tencha* showed a very faint black colour. The solubility of tea was determined as follows:—

400 cc. of boiling water were poured on 10 gr. of the powdered sample which had been kept at 100°C for an hour. It was filtered after leaving it to stand for 5 minutes and washed on the filter with 100 cc. of boiling water, and the soluble matters were estimated in it.

The Composition of the control tea was as follows:—

In 100 pts. of air dry substance	
Water ... ..	6.215
In 100 pts. of dry substance	
Crude protein ... ..	41.984
Albuminoids ... ..	28.252

1) Bulletin of College of Agriculture and Dendrology No. 7.

2) *König*. Chemie der Nahrungs-und Genussmittel B. II.

Ethereal extract	...	...	...	...	...	9.042
Crude fiber	...	...	...	...	...	12.012
Nitrogen free extract	...	...	...	...	...	14.101
Thein	...	...	...	...	...	3.529
Tannin	...	...	...	...	...	15.968
Crude ash...	...	...	...	...	...	6.883
Total nitrogen...	...	...	...	...	...	6.717
Albuminous nitrogen	...	...	...	...	...	4.520
Thein nitrogen...	...	...	...	...	...	0.934
Amide nitrogen	...	...	...	...	...	1.263

The soluble constituents of the three samples were as follows:—

In 100 pts. of dry matters

	Control	<i>Tencha</i>	<i>Gyokuro</i>
Dry matter... ..	34.057	34.130	33.862
Tannin ... ..	7.083	6.939	6.477
Thein ... ..	3.124	2.996	3.088
Ash ... ..	5.249	5.373	5.197

According to these results *Gyokuro*, which was prepared by rolling the leaves, showed no greater solubility than the other two. Soluble tannin decreased in *Gyokuro*, probably in consequence of oxydation during the rolling.

In the other experiment I determined the solubility of three samples in a different manner. 10 gr. of whole, not powdered sample were put in a beaker and after keeping it at 100°C for an hour, 200 cc. of boiling water were poured on and filtered through glass wool, after leaving it to stand for 5 minutes. In the filtrate dry substance, crude protein, tannin, thein and ash were estimated. They were as follows:—

In 100 pts. of air dry substance

	Control	<i>Tencha</i>	<i>Gyokuro</i>
Water ... ..	8.375	7.953	7.638

In 100 pts of dry matter there were soluble

Dry matter... ..	16.076	21.190	29.233
Nitrogen ... ..	1.885	2.141	2.313

Tannin	... ..	0.659	1.312	5.492
Thein	... ..	1.975	2.243	2.804
Ash	... ..	3.405	4.411	4.385

In 100 pts. of each constituent there were soluble

Dry matter...	... ..	17.545	23.021	31.656
Nitrogen	... ..	28.068	31.869	34.427
Tannin	... ..	4.127	8.216	34.374
Thein	... ..	55.965	63.559	79.453
Ash	... ..	49.750	64.083	63.708

The increase of solubility compared with the control was found to be as follows:—

	<i>Tencha</i>	<i>Gyokuro</i>
Dry matter	... .. 5.476	14.111
Nitrogen	... .. 3.801	6.359
Tannin	... .. 4.089	30.247
Thein	... .. 7.594	23.488
Ash	... .. 14.333	13.958

We see that, when the whole, not powdered samples were used, there was a greater increase of solubility in the rolled leaves. Hence we may conclude that the rolling of tea leaves has the effect of increasing easily soluble matter by crushing the cells and pressing out the juice and making it dry on the surface of the leaves.

A second experiment on the same subject was carried on in 1906 with tea leaves picked in an unsheltered tea garden. The leaves were divided into two parts and one part was dried after steaming and served as control, and the other part prepared into green tea.

The infusion of the two samples was found to be as follows:—

	Control	Green Tea.
Colour	light	common
Flavour	nearly null	good
Taste	faint	good

The composition of the original leaves was found to be as follows:—

In 100 pts. of air dry substance

Water	...	...	...	...	...	...	...	6.008
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In 100 pts. of dry substance

Crude protein	...	...	...	...	...	...	33.209
Ethereal extract	...	...	...	...	...	...	25.656
Tannin	...	...	...	...	...	...	18.889
Thein	...	...	...	...	...	...	3.266
Ash	...	...	...	...	...	...	5.719
Soluble matter	...	...	...	...	...	...	44.525
Total nitrogen	...	...	...	...	...	...	5.313
Thein nitrogen**	...	...	...	...	...	...	0.864

The solubility which was determined in whole, not powdered samples, was found to be as follows:—

In 100 pts. of dry substance

	Control	Green Tea
Dry matter	9.879	26.692
Nitrogen	0.969	1.410
Tannin	4.883	12.802
Thein	1.995	2.136
Ash	1.383	3.077

In 100 pts of each constituent there were soluble

	Control	Green tea	Increase in green tea
Dry matter...	22.119	59.948	37.829
Nitrogen	18.227	26.531	8.304
Tannin	25.850	67.778	41.928
Thein	61.074	65.403	4.329
Ash	24.186	53.811	29.625

The result of these trials agreed with that of the former one, showing the increase of solubility in the rolled leaves. Hence we may conclude that the chief effect of rolling tea leaves is the increase of easy



solubility of the constituents. The dessication of the leaves will also be accelerated by rolling and pressing out the juice from the interior of the cells. From these facts we are justified in testing tea-infusions by taking the whole leaf, not the powdered sample, and infusing it for only a few minutes. Total solubility as determined by the usual method is not of much use for practical purposes.

### III. THE EFFECT OF FIRING ON THE CHEMICAL COMPOSITION OF TEA.

Green tea as well as black tea are usually refired some days after the manufacture. By refiring the flavour is much improved, but the infusion becomes usually darker in colour. In 1908 and 1909 I made some investigations on the effect of refiring on the quality and composition of tea. I kept green tea and black tea respectively at various temperatures for one hour and then analyzed. Tannin was estimated by *Löwenthal's* method and then by *Muller's* method. Solubility was determined by infusing 2 gr. of whole tea leaves in 400 cc. of distilled water for 2 hours, and after 100 cc. of water had been added it was filtered. The temperature used for firing, the colour and flavour of the infusion and the colour of the infused leaves were found to be as follows:—

1908

#### 1. Green tea.

No.	Temperature	Colour	Flavour	Colour of the infused leaves
1	Control (not fired)	little lighter than No. 3	weaker than No. 2	} greenish yellow
2	61°C	nearly same as No. 3	1 est	
3	82°C	best	little too strong	
4	101°C	rather red	} bad smell	little reddish
5	123°C	more reddish than No. 4		} reddish
6	140°C	more reddish than No. 5		
7	160°C	reddish		blackish brown

#### 2. Black tea.

1	Control (not fired)	lighter than No. 2	weaker than No. 2	} brown
2	62°C	lighter than No. 5	weaker than No. 3	
3	81°C	lighter than No. 1	best	
4	101°C	lighter than No. 3	} bad smell	
5	119°C	most reddish		} blackish brown
6	141°C	lighter than No. 4		
7	156°C	lighter than No. 6		

1909

## 1. Green tea.

No.	Temperature	Colour of infusion	Aroma of infusion	Taste of infusion	Colour of the infused leaves
1	Control (not fired)	faint	weak	weak	} usual
2	60°C	best	"	astringent	
3	70°C	lighter than No. 4	best	good	
4	80°C	lighter than No. 2	good	best	
5	90°C	reddish	} bad	bitter	} little burnt
6	100°C	worst		most bitter	

## 2. Black tea.

1	Control (not fired)	not clear	} faint	weak	} usual
2	60°C	} light		good	
3	70°C		best	best	
4	80°C	best	weaker than No. 3		
5	90°C	worse than No. 4	} bad	} bad	} blackish
6	100°C	blackish			

The chief constituents of the tea were found to be as follows:—

1908

No.	Temperature	In 100 pts. of air dry substance water	In 100 pts. of dry substance				
			Tannin	Thein	Solubility	Soluble tannin	Soluble thein

## 1. Green tea

1	Control (not fired)	5.228	15.690	3.210	37.458	11.724	2.506
2	61°C	4.633	—	—	36.786	11.906	2.000
3	82°C	3.158	—	—	35.417	117.85	2.601
4	101°C	1.383	14.602	3.101	35.553	11.688	2.444
5	123°C	2.045	—	—	37.364	11.096	2.455
6	140°C	2.453	—	—	35.162	10.400	2.287
7	160°C	3.005	13.248	3.098	29.898	6.470	2.317

## 2. Black tea

1	Control (not fired)	3.445	8.575	3.075	27.393	4.045	2.518
2	62°C	3.985	—	—	27.027	4.151	2.076
3	81°C	3.703	—	—	27.415	4.390	2.290
4	101°C	2.293	7.247	3.130	27.020	4.450	2.705
5	119°C	4.875	—	—	26.281	3.082	2.477
6	141°C	2.230	—	—	24.957	2.594	2.443
7	156°C	1.400	5.797	3.135	22.757	1.001	2.500

1909

No.	Temperature	In 100 pts. of air dry substance water	In 100 pts of dry substance				
			Tannin	Thein	Solubility	Soluble tannin	Soluble thein
1. Green tea.							
1	Control (not fired)	5.157	15.857	3.077	37.557	11.621	2.191
2	60°C	4.512	15.844	3.134	37.252	11.883	2.425
3	70°C	3.903	—	—	37.463	11.936	2.483
4	80°C	3.168	15.418	3.209	36.455	11.711	2.536
5	90°C	2.105	—	—	35.569	11.236	2.442
6	100°C	1.844	14.586	3.061	24.666	11.451	2.487
2. Black tea.							
1	Control (not fired)	6.320	8.484	3.165	27.556	3.917	2.348
2	60°C	4.541	8.632	3.163	27.137	3.844	2.456
3	70°C	3.574	—	—	27.378	3.955	2.403
4	80°C	3.218	7.402	3.147	27.098	3.979	2.407
5	90°C	2.271	—	—	26.727	3.479	2.221
6	100°C	2.049	7.093	3.046	26.475	3.283	2.200

From these results we may conclude that green tea is improved in quality by being fired at 70°C for one hour, a temperature higher than 70°C spoils both the flavour and colour. The optimum temperature for firing black tea lies a little higher than for green tea; viz. 80°C, and like green tea a higher temperature spoils the flavour and colour. By refiring tannin and thein decrease more or less, probably the former being due to oxydation and the latter to volatilization. Solubility increases little when tea is not strongly heated, but when the temperature is high, the total soluble substance and tannin decrease remarkably. Therefore in firing tea the temperature must of course be properly applied. If it is too high the quality of tea is much deteriorated.



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# BULLETIN

OF THE

IMPERIAL CENTRAL AGRICULTURAL  
EXPERIMENT STATION

IN

JAPAN



Vol. II, No. 2

K.

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NISHIGAHARA, TOKIO

FEBRUARY, 1919





農事試驗場歐文報告

第二卷第二號



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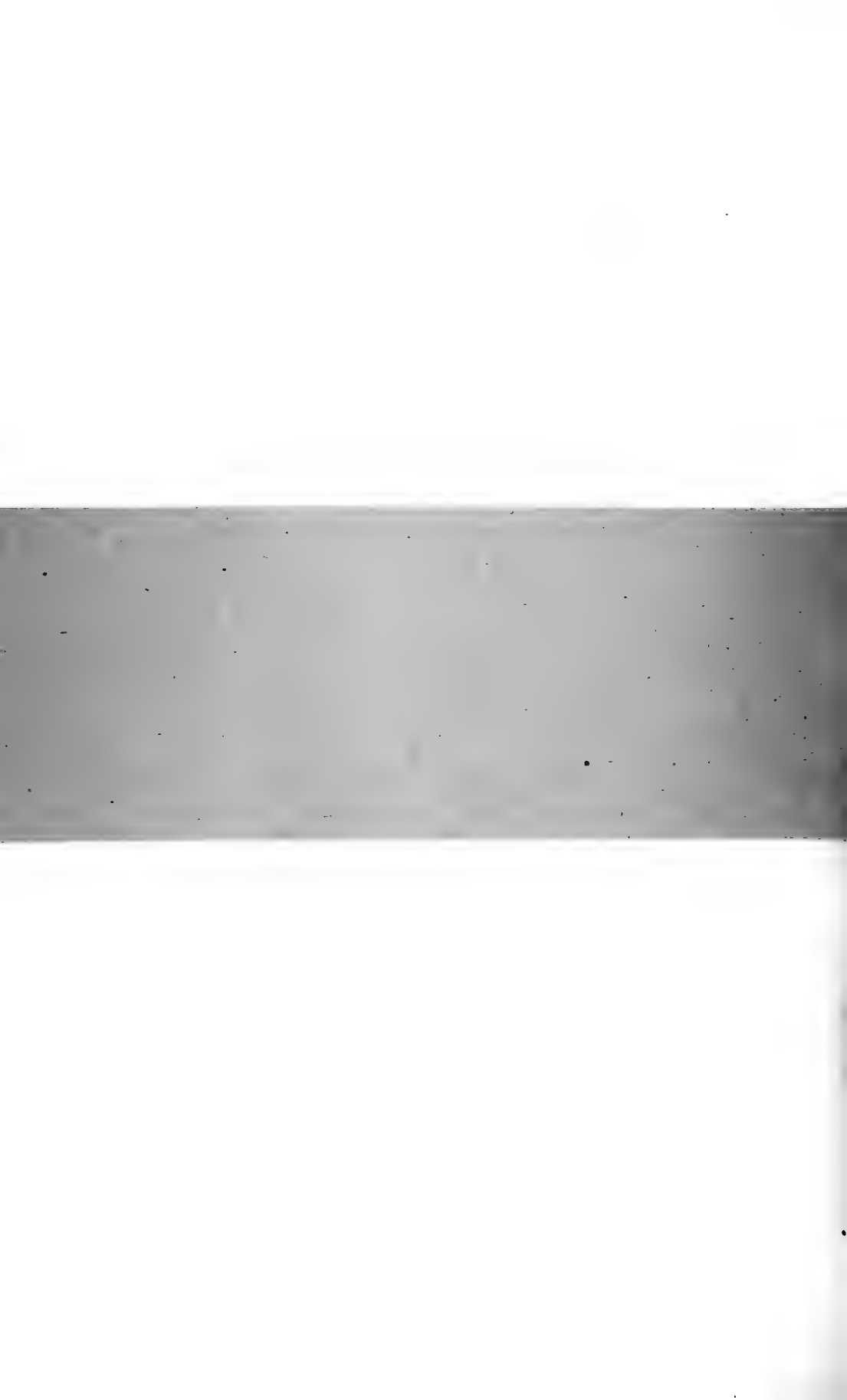


**N. B.** Please note postscript on page 158!

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ERRATA.

- P. 99, line 10 from bottom, change **R4+5.** and **M1+2.** into **R4+5.** and **M1+2.**, and line 8 from bottom, **M1+2.** into **M1+2.**
- P. 101, line 15 from top, for **this** read **the**.
- P. 108, line 5 from bottom and P. 112, line 14 from bottom, for **segment** read **segments**.



# Studies on the Fruit-Flies of Japan.

## CONTRIBUTION I.—Japanese Orange-Fly.

BY

TSUNEKATA MIYAKE, *Rigakushi, Rigakuhakushi, F.E.S.*,

Government Entomologist.

With Plates II.—X. and five Text-Figures.

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## I. INTRODUCTION.

Japan, like other countries, is not exempt from the attacks of various noxious insects, yet the orchards in the Main Island (Honshiu) are not suffering at present from any injury caused by fruit-flies (Trypaneidae). It is true that certain species of flies belonging to the family are found in Honshiu, yet, so far as I could observe, none of them seem to cause any damage at all to our orchard fruits.<sup>1</sup> Recently it was reported that the fruit of *Elaeagnus* in the Prefecture of Shidzuoka,<sup>2</sup> and cherries in the Prefectures of Akita and Aomori,<sup>3</sup> were infested by some dipterous insects, but after examination, I could confirm that they were not Trypaneids. Some observant people in Honshiu may be acquainted with certain lepidopterous larvae burrowing in the pulp of the pear and the peach, but no one would ever suspect that there are maggots in the pulp of the orange. However, it is occasionally reported that, in the warmer parts of Japan, Kiushiu and Formosa, there occur some fruit-infesting maggots, which cause not inconsiderable injury to oranges. Though very few Trypaneids have been reported from Japan proper,<sup>4</sup> yet quite a large number have recently been mentioned as from Formosa by HENDEL (12, 13)<sup>5</sup> and ENDERLEIN (8), and now we know that the very injurious orange-infesting species, commonly known as *Konikanbai* in that

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1. Quite recently I was informed that, at some localities in Gifu Prefecture a Trypaneid, apparently *Chaetodacus* (but not *C. cucurbitae*) was discovered, which infests the pumpkin. TAKAHASHI (32) gives some details. (The figures in parentheses refer to the bibliography appended at the end of the present paper.)

2. OKADA (24).

3. NISHIGAYA (23).

4. Prof. MATSUMURA of the Sapporo Agricultural College has described (21, p. 117, Pl. xxviii, fig. 8) 1 species occurring in Hokkaidō, and (22, pp. 411-423, pl. xxiii, figs. 9-19) 11 Trypaneid species assuming all to be true Trypaneids<sup>1</sup>, of which 8 occur in Japan proper, 1 in Loochoo, 1 both in Japan and in Formosa, and 1 both in Japan and in Saghalien.

5. Figures in parentheses refer to the bibliography.

island is referable to *Dacus*<sup>1</sup> (*Chaetodacus*) *ferrugineus dorsalis* of HENDEL. On the other hand, so far as I know, no species from Kiushiu has been described systematically. It has been stated that the well known injurious melon-fly (*Dacus* (*Chaetodacus*) *cucurbitae* Coquillett) was reared by COMPERE (3, p. 4) from melons and cucumbers collected at Nagasaki, a port in Kiushiu, and if this is really so, there can be no objection to including Kiushiu in "Japan," as used by PERKINS (28, p. 179) and CRAW (3, p. 4) in their works (The former author maintains the true home of the fly to be Japan or China, and the latter states, that the fly was introduced from Japan into Hawaii). However, since repeated investigations made by me at Nagasaki failed to confirm these statements, I am confident that they are incorrect.<sup>2</sup>

On the other hand, the presence of a certain orange-infesting fruit-fly has repeatedly been reported of late from the orchards of Kiushiu, and now and then it has also been mentioned by our entomologists in various Japanese journals. By KUWANA (17), the species was referred to *Dacus* (*Chaetodacus*) *ferrugineus* Fabricius, and its morphology, brief life-history, distribution and control measures were described by him in the Report of the Imperial Agricultural Experiment Station (18).

In 1914, I was asked by the Department of Agriculture and Commerce to inspect the actual conditions of this orange-pest infestation in the invaded districts of Kiushiu. The results of my observation were afterwards presented to the authorities in an official report, which consisted of itinerary records and some scientific investigations. From my inspection, I am able to state that there have been two species of fruit-flies occurring at the orange groves of the invaded districts of Kiushiu, the one, the species known as very injurious and identified as *Dacus ferrugineus* Fabricius by KUWANA, the other, hitherto an unrecorded species, which I considered to be new to science and which I have named

1. I use here the broad generic name; for the reason see p. 92.

2. While the present work was in the press I received a paper "The Melon Fly" by BACK and PEMBERTON (U. S. A. Dept. Agric. Bull. No. 643, March 8, 1918), in which the former statement was more or less amended to:—"There is some doubt at present about its occurrence at Nagasaki, Japan."



*Dacus* (*Chaetodacus*) *bezzii*. My subsequent study revealed that the former species was also a new species, to which I have given the new name *Dacus tsuneonis*. The two species were found abundantly at the localities, either singly or in company with each other. Though it is quite obvious that *Dacus tsuneonis* is a formidable pest to the orange, yet *Dacus* (*Chaetodacus*) *bezzii*, abundant as they are at the orchard, have afforded as yet no positive proof of causing injury to the orange. I, therefore, first began with the study of the injurious species *Dacus tsuneonis*, intending in the course of my research, to extend the investigation over the other species, *Dacus* (*Chaetodacus*) *bezzii*, as well as over the whole family of Trypaneidae occurring in Japan. Now that my study on *Dacus tsuneonis* has been nearly completed, I intend to publish what is ready, as the first contribution of my study of the Trypaneidae or fruit-flies of Japan. At the same time, I make use of this occasion to touch upon the specific description of *Dacus* (*Chaetodacus*) *bezzii*, as well as on the descriptions of four other new Trypaneid species, which have been discovered during the course of my study.

Since the presence of this pest is strictly restricted to a limited area in Kiushiu, orchardists of the Main Island of Japan need not be unduly alarmed, though some appropriate precaution against such injurious insects may not be altogether unnecessary. Still less need foreign fruit importers be alarmed, as fruits from these localities are not exported.

To investigate the possible injury by fruit flies, other government entomologists besides myself were sent in 1916 to the principal orange growing districts of the Main Island, but not a single trace of the presence of any fruit-fly was found in the localities traversed. In spite of this it is desirable to keep constant watch and guard against invasion by the above-mentioned species as well as other fruit-flies.

The author desires to express here his hearty thanks to Prof. M. BEZZI of Italy, who has favoured him with much valuable advice in the course of this investigation. Grateful acknowledgments are also due to MESSRS. K. W. DAMMERMAN, W. W. FROGGATT, W. M. GIFFARD, L. O. HOWARD, J. F. ILLINGWORTH, C. W. MALLY, J. C. H. DE MEIJERE,

F. MUIR, W. C. O'KANE, H. H. P. SEVERIN, H. C. SEVERIN, F. SILVESTRI, N. YATSU and many others, for friendly information and for the loan of important papers. Further indebtedness is also acknowledged in the text to other gentlemen who have extended their courtesy to the author in special matters.

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## II. HISTORY, DISTRIBUTION AND DESTRUCTIVENESS.

Of the early history of the species under consideration I cannot say anything with certainty, yet it is highly probable that the fly is an indigenous species, inasmuch as it has not been recorded from other parts of the world. With regard to the question as to the place in Kiushiu where it originated, I cannot give any definite answer, although we naturally suppose it to be somewhere in Ōita or Miyazaki Prefecture, since the flies are at present very abundantly found in those prefectures.

As said before the occurrence of the present species is strictly limited to Kiushiu and the following table gives the detailed distribution in that island:—

Ōita Prefecture.....	{	Ōita City.....	{	Tsugumi Village, Aoye
		Kita-amabe District .....		Village, Shitaura Vil-
		Minami-amabe District ...		lage, Hijiro Village,
				Usuki Town.
Miyazaki Prefecture...	{	Higashi-morokata District.	{	Takaoka Village, Aya
		Koyu District.....		Village.
				Mino Village, Kamiho-
		Higashi-usuki District ...		kita Village.
		Nishi-usuki District .....		Nobeoka Town, Oka-
				tomi Village, Tsune-
				tomi Village, Minami-
				kata Village, Kita-
				kata Village.
Kumamoto Prefecture.	{	Hōtaku District .....	{	Kawachi Village.
		Tamana District.....		Obama Village.
Nagasaki Prefecture...	{	Kita-matsuura District ...	{	Hirado Village.

Kagoshima Prefecture.	Kagoshima District .....	Sakurajima Village,
		Nishisakurajima Village, Take Village, Fujino Village.
	Aira District .....	Fukuyama Village, Ya- mada Village.
Fukuoka Prefecture <sup>1</sup> ...	Yame District .....	

Of the localities above mentioned, the injury is more serious in Ōita, Miyazaki and Kumamoto Prefectures than in any other.

An exact estimation of the damage is impossible, since it varies from year to year according to climatic and many other conditions. Speaking generally, however, where the destruction is severest, it is said, often to amount to 40%–50% of the whole harvest, yet usually it is 10%–20% or still less. Fortunately, according to reports recently received from the various infested localities, the damage is being reduced year by year chiefly owing to the improvement and strict execution of preventive measures.

### III. TECHNICAL DESCRIPTION.

#### 1. SYSTEMATIC DESCRIPTION.

*DACUS*<sup>2</sup> *TSUNEOVIS*<sup>3</sup> n. sp.

(Nom. Jap. *Mikanbai*.)

(Pl. II., fig. 1, ♀; Pl. X., fig. 1,—wing.)

*Dacus ferrugineus* Kuwana (nec Fabricius), (17), p. 109 (1911).

A conspicuously large species, the prevailing colour of the body ochreous; all the bristles are black.

1. The occurrence of the fly has been reported here, but cannot be verified.

2. Here I have to adopt the genus *Dacus* in a broad sense and do not use it as a subgenus or small genus (some authors elevate the subgenus into the genus), since the present species cannot be included in any subgenus hitherto described, so that a new subgenus (I call it *T. tridacus*), must especially be created in order to include the species. However, at present, I entertain some doubt as to whether it is scientifically proper to establish a new subgenus, taking merely such a very small point into account. For this reason in the present paper, all the species are included within the broad genus *Dacus*, without using any subgenus such as *Chaetodacus*, *Baetocera*, etc.

3. Named after my dear son, TSUNEO who was born in 1914, when I began the present study, and who died in 1916, when I finished the first draft of this contribution.

Head yellow or ochreous; ocellar triangle black; frons in some specimens tinged with fuscous; antennal ridge in most specimens dusted with fuscous; Eyes reddish brown, with dark-green reflection<sup>1</sup>; two shining black claviform spots on the clypeus; a small subtriangular piceous spot in the middle of each gena, just below the lower margin of the eye; antennae ochreous, the arista piceous, with the base yellow; proboscis, with a piceous ridge at the base, mottled with brown, the palpi yellow.

Thorax densely punctate, with short yellowish pubescence, ferrugineo-ochreous; a median longitudinal  $\Lambda$ -shaped purplish testaceous streak on the dorsum, terminating posteriorly in the centre of the scutum; a pair of rather faint submedian, more or less wavy, purplish testaceous lines, interrupted at the transverse suture and united posteriorly with the posterior branches of the  $\Lambda$ -shaped streak just mentioned; a yellowish patch, often defined internally with piceous line on each humeral callus, extending posteriorly to the transverse suture; an anteriorly acutely-pointed, subtriangular yellow spot on the space, bounded by the posterior branches of the  $\Lambda$ -shaped streak; a long lunular yellowish streak defined internally with a piceous line on each side of the spot just mentioned, commencing anteriorly at the transverse suture and ending posteriorly before the junction of the scutellum; anterior and posterior supra-alar bristles double; scutellum yellowish, with two bristles; the median plate of the scutellum ochreous; the lateral sides of the thorax ochreous, except the postscutellum and most of the lateral plate of the mesosternum, which are yellow; an elliptic yellow patch at the mesosternum, close to the suture; halteres ochreous; the chaetotaxy is peculiar, with two pairs of supra-alar bristles and without praescutellar bristles.

Legs ochreous, with yellow pubescence; the apical margin of the fore coxae and the internal sides of the mid coxae with a few black hairs; end of all the femora, base and end of all the tibiae, and distal

---

1. In the living specimen they are bright green with purplish reflection.

joints of all the tarsi, brownish; the internal sides of end of the femora and end of the tibiae often with a testaceous streak.

Wings hyaline, with more or less greyish tinge; veins fusco-ochreous; pterostigma fusco-ochreous; the area between veins  $R_1$ . and  $R_4+5$ . tinged with honey-yellow; radial cell at the region above the medial and cubital cells also honey-yellow; a fuscous suffusion at the apex of the wing; The second axillary lobe wanting in the male.

Abdomen oval, as broad as the thorax, densely punctate, bright ochreous above, yellowish beneath, and brownish at the end, with a short yellowish pubescence; a longitudinal median black, rather broad, streak from the base to the end of, or four-fifth of, the apparent fifth segment,<sup>1</sup> where it is usually attenuated; the streak is slightly dilate at the anterior margin of the second segment; along the anterior margin of the third segment, there is a slightly broader, transverse piceous band which constitutes a cross marking with the above-mentioned longitudinal streak; a pair of still broader, transverse testaceo-piceous bands at the anterior margin of the fourth segment, neither confluent with each other nor with the longitudinal streak; in some specimens, there is often another pair of piceous bands at the anterior margin of the fifth segment.

In the male there is a row of black hairs (7-10 in number) on the sides of the posterior margin of the third segment; in the female the basal segment of the ovipositor (apparent seventh segment) is bottle-shaped, ferrugineo-ochreous, as long as the fourth and fifth abdominal segments taken together.

Male. Length of body 10 mm.; length of wing 9 mm.

Female. Length of body 11 mm. (measured to the origin of the basal segment of ovipositor); length of wing 10 mm.

Described from 10 male and 10 female specimens captured at Tsugumi, on Aug. 28, 1915; besides many others examined.

*Local Distribution.* Ōita, Miyazaki, Kumamoto, Nagasaki, Kagoshima, Fukuoka (?).

1. For convenience sake, here as well as in subsequent systematic descriptions, the visible abdominal segments alone are numbered.

*Habitat.* Kiushiu.

This species was first reported from Japan as *Dacus* (*Chaetodacus*) *ferrugineus* Fabricius by KUWANA (17, 18). However it entirely differs in its chaetotaxy as will be described later. It is also different from *Dacus* (*Chaetodacus*) *ferrugineus* described by WIEDEMAN, in the markings of the abdomen, and from that by BEZZI, in its black bristles. Furthermore, the present species is larger than *ferrugineus*, which is reported to be 5-7 mm. in length. Specimens have been submitted for examination to Prof. BEZZI, who remarked that it differs from *ferrugineus* by its black head bristles and by the peculiarity of its ovipositor.

The present species does not bear the praescutellar bristles, and in the male the hind border of the wing is not indented at the end of the anal vein. In these, also in many other respects, it is closely related to the Ethiopian species and stands very near the subgenus *Tridacus*.<sup>1</sup> However, in the present species, there are four supra-alar bristles, both anterior and posterior being paired, so that if the subgenus may be adopted, a new subgenus *Tetradacus*, with four supra-alar bristles, should be created to include the present species.

## 2. EXTERNAL STRUCTURE OF THE ADULT FLY.

### a. HEAD<sup>2</sup> (Pl. II., figs. 10, 11, 12).

The head of this insect is comparatively large, and contains many regions, on the morphological terms for which there are, as in other flies, many different opinions. The top of the head we call the vertex (Pl. II figs. 10, 11, *v.*), where three ocelli (*s. e.*) are situated on the raised black ocellar triangle. The front of the vertex is the frons (*f.*), which bears three pairs of bristles, the hind pair of which are bent backwards and are called the superior front orbital bristles (*s. f. o.*), and the middle and front pairs, which are bent inwards, are called the inferior front orbital

1. BEZZI (5, p. 86).

2. In the following description, I mostly adopt HEWITT'S orismology employed in his "House-Fly" (14), excepting names of bristles and other portions of the body which are peculiar to the fruit-fly. For these I mainly follow BEZZI'S usage.

bristles (*i. f. o.*). Lateral to the frons and the vertex are a pair of large hemispherical compound eyes (*c. e.*), reddish purple in colour, with metallic blue-green reflection in life, and dark reddish purple with slight green reflection after death. The lower part of the frons forms a ridge (fig. 11, *a. r.*) ("antennal ridge" according to LOWNE, 19), below which arise the antennae (figs. 10, 11, *a.*), each of which consists of three joints and the arista. The sclerite below the antennae is called the clypeus,<sup>1</sup> (fig. 11, *c.*) or the face, and the region between this and the compound eyes is known as the gena (fig. 11, 12, *g.*), which bears the genal bristles (fig. 11, *g. b.*). The lower edge of the clypeus, which forms the margin of the so-called proboscis aperture, is the episternum (*e.*). To the proboscis aperture the retractible proboscis is attached, which is composed of two portions—the rostrum and the haustellum. The rostrum (figs. 11, 12, *r.*), which is the portion proximal to the head, has the shape of a truncated cone, and bears on its lower side a pair of rather conspicuous leaf-like appendages known as the maxillary pulpi (*mx. p.*). The haustellum (fig. 11, *h.*), the distal portion, is again composed of two parts—the proximal conico-cylindrical and distal lobe-like parts, of which the former is said to represent morphologically a certain part of the labium. The posterior side<sup>2</sup> of the part is known by the name of the theca (fig. 12, *th.*). On the anterior<sup>3</sup> median line, there lies a claviform process, arising from the basal portion of the haustellum. This is called the labrum-epipharynx (fig. 11, *l. ep.*), morphologically considered it corresponds to the labrum and epipharynx. Beneath the labrum-epipharynx is a longitudinal groove, lined with chitinous ridges well adapted to receive the processus. In some other kinds of flies there is usually another processus called the labium-hypopharynx, under the labrum-epipharynx just mentioned, but so far as my examination went, I could not find any corresponding organ in this species. However, in certain cases, I found a very small, short, quadrate piece at the root of the labrum-

1. LOWNE (19) applies this term to the basal portion of the proboscis.

2, 3. The words "anterior" and "posterior" are applied to the proboscis in position, as it hangs perpendicularly from the head capsule.



epipharynx, which, if I am not mistaken, may be considered as the labium-epipharynx. At the end of the haustellum, is a fleshy, broadly U-shaped disc, called the oral lobe or labella (figs. 11, 12, *o.l.*), which is for sucking food. The distal surface of the labella contains a number of channels, called the pseudo-trachaea (fig. 12, *p.s.*).

On the posterior side of the head, one may find the occipital foramen (fig. 12, *o.f.*) in the centre, around which there are four sclerites, the middle dorsal one of which is the occiput (*oc.*) (HEWITT calls it the epicranium and LOWNE the mesocranial plate), the middle ventral one the gulo-mental plate (*g.m.*) (or pars basilaris), and the lateral two are known as the genae (*g.*) (HEWITT) or paracephala (LOWNE).

b. *THORAX* (Pl. II., figs. 3, 4, 13).

The thorax of the present insect, like that of other flies, represents a considerable modification. The entire segment, which is chiefly composed of the mesothorax, constitutes a slightly elongate box, which is oviform when seen from above. The prothorax is very small, only visible at the anterior side of the main thoracic segment. The lateral region of the prothorax is chiefly represented by a sclerite (the episternum, according to HEWITT) and there the anterior thoracic spiracle lies (Pl. II., figs. 3, *t.s.*) between this and the mesothoracic sclerite. Of the mesothorax, the notum constitutes almost the entire dorsal surface of the thorax and is composed of the praescutum, scutum, scutellum and the postscutellum. The praescutum (figs. 3, 13, *prs.*) is a sclerite of transverse rectangular form, bounded laterally by the portion called the humerus (*hu.*) and posteriorly restricted by the transverse suture (*t.s.*). The anterior edge of the praescutum bears two pairs of the bristles called scapular bristles (figs. 4, 13, *scp.*), and the humerus bears the humeral bristles. The scutum (figs. 3, 13, *sc.*), which constitutes the largest portion of the mesonotum, is quadrate in shape, and bears, along the lateral sides, the bristles called the anterior and posterior, notopleural (figs. 4, 13, *a. npl.*; *p. npl.*) and supra-alar (*a. sa.*; *p. sa.*) bristles. Of the latter bristles, both the anterior and posterior supra-alar bristles are double in number. The praescutellar bristles, the presence of

which according to BEZZI (4, p. 92) is said to be characteristic of the allied Oriental species, are absent in this species.<sup>1</sup> The scutellum (figs. 3, 13, *scell.*) is a triangular convex sclerite and bears a pair of bristles called the apical bristles (*a. b.*) in relation to the basal bristles, which are often present in other species. The postscutellum, which is situated behind the scutellum, is composed of three portions, one median (*mp. sc.*) and two lateral plates (*lp. sc.*). Laterally the mesothorax represents highly complicated sclerites and sutures. According to the orismology of HEWITT—the lateral plate of the mesosternum (fig. 3, *lp.*) is a quadrate plate with two sutures and bears the mesopleural bristles (fig. 4, *mpl.*). The episternum, if my orientation be correct, is the narrow region (fig. 3, *eps.*) posterior to the lateral plate, above which we see the sclerite of the parapteron (*p.tr.*). The epimeron (*ep.*) is a subquadrate plate posterior to the episternum, and above it we see the base of the wing. The epimeron bears the pteropleural bristles (fig. 4, *pt. b.*). The mesosternum (fig. 3, *ms.*) is a large triangular plate attached to the lateral plate and to the epimeron just mentioned. The metathorax is greatly reduced and the main part is represented by the metasternum (*mts.*). Just above it is a small oval plate (unmarked in fig. 3), which is probably a portion of the metasternum. Posterior to the metasternum and the lower part of the lateral plate of the postscutellum is an elongate portion (fig. 3 *eps.+ep.*), making the lower posterior edge of the thorax. In *Musca domestica* Linnaeus, according to HEWITT, the portion is divided into two sclerites, the episternum and the epimeron, while in our species, so far as I could ascertain, it appears to be a single plate, the two sclerites possibly having been united. On the upper part of the plate the posterior thoracic spiracle (*p. t. s.*) is situated and above the spiracle is the balancer (figs. 3, 13, *bal.*) or haltere, possibly having originated from a special sclerite.

*WINGS* (Pl. III., fig. 14; Pl. V., fig. 1).

The fore wings, which represent the wings of the fly, are situated at the sides of the scutum of the mesothorax, above the epimeron of the same segment. They are elongate, membranous and almost transparent,

1. As to discussion of the subgeneric character see p. 95.

except for a portion tinged with brown. Applying COMSTOCK and NEEDHAM's nomenclature of veins to the present species, there are six kinds of longitudinal veins and a few small cross veins in all, presenting the typical neuration of Muscidae. Indeed, the fruit-fly is still placed in that family by some authors, but differing in several small points it is rather distinct. The costa (Pl. III., fig. 14 *C.*) forms the anterior margin of the wings and is bristly in the species. The subcosta (*Sc.*) arises from the common stalk of the subcosta and the radius (*Sc. + R.*), running parallel with the first radial branch (*R* 1.) and ending at the costa, where, in this species, it becomes very indistinct. Between the costa and the subcosta there is a cross vein called the humeral (*h. v.*), by which the costal cell is divided into two cells. The proximal cell (*C.*) is called the costal cell (according to HEWITT, 14) or first costal cell (according to BEZZI, 4), and the distal cell (*1 C.*) is called the first costal cell (HEWITT) or second costal cell (BEZZI). The radius arises from the common stalk (*Sc. + R.*) just mentioned and is forked into three branches *R* 1., *R* 2 + 3. and *R* 4 + 5., where the typical radius has five branches. In the species the first radial branch (*R* 1.) and the basal half of the coalesced fourth and fifth radial branches (*R* 4 + 5.) are bristly. Next, from a rather inconspicuous common stalk, possibly the united portion of the media and the cubitus (*M. + Cu.*), two well distinct diverging veins arise, the upper one being the united vein of the first and the second medial branches (*M* 1 + 2.) and the lower one the coalesced vein of the second medial and the first cubital branches (*M* 3. + *Cu* 1.). Between the *R* 4 + 5. and *M* 1 + 2. is a cross vein termed the radio-medial transverse vein (*rm.*) (according to HEWITT), or small cross vein (according to BEZZI). Between the *M* 1 + 2. and *M* 3. + *Cu* 1. are two cross veins, of which the proximal one, called the medio-cubital vein (*m. cu.*) (according to HEWITT) or basal cross vein (according to BEZZI), is said to represent the original *M*<sub>6</sub>, the distal one being called the medial transverse vein (*m.*) (HEWITT) or hind cross vein (BEZZI). The cell bounded by the veins *M* 1 + 2. and *M* 3. + *Cu* 1. is divided by the above-mentioned two veins into three cells. The most proximal cell is called the medial cell (*M*) (HEWITT) or second basal cell (BEZZI), the

next cell the first second-medial cell ( $2M^1$ ) (HEWITT) or discoidal cell (BEZZI), and the distal cell is termed the second second-medial cell ( $2M^2$ ) (HEWITT) or second posterior cell (BEZZI). The second branch of the cubital vein ( $Cu2$ ) (anal cross vein of BEZZI) is partly coalesced with the first anal (1st  $A$ .) at the distal portion. The first anal is as distinct as the other vein, though it is distally fused.

From the base of the anal lobe (*an.*) arises a rather inconspicuous vein (*c. f.*) (axillary vein of BEZZI) which is said to be merely a chitinised furrow and not a true vein. The second axillary lobe is wanting in the male.

*HALTERES* (Pl. II., figs. 3, 13).

As the present species belongs to the acalyptrate Muscidae, the halteres or the balancers (*hal.*) are not covered by the squamae. They are situated above the posterior thoracic spiracles (fig. 3, *p. t. s.*), quite posterior to the thoracic segment, and are of capitate form.

*LEGS* (Pl. III., fig. 15, 16).

The legs are composed of the typical segments, *i. e.* coxa (*cx.*) trochanter (*tr.*), femur (*fe.*), tibia (*t.*) and tarsus (*tar.*). On the coxae of the mid and hind legs, there are special regions called the intermediate coxal plates (*c. p.*). On each of the middle legs I could find two intermediate coxal plates, while on the hind legs, as far as I could ascertain, a single plate only was found. The trochanter and subsequent joints are almost similar in all legs. On the inner side of the distal end of the middle tibia are a few piceous setae, one of which is rather prominent. The tarsus is five jointed, with a pair of claws (figs. 15, 16, *cl.*) at its apex, resting on a pair of pads called the pulvilli (figs. 13, 16, *pul.*).

c. *ABDOMEN* (Pl. II., figs. 8, 9; Pl. III., figs. 1, 2, 3, 4).

The shape of the abdomen of this insect differs in the sexes. In the male it is elliptical (Pl. III., figs. 1, 2); in the female, owing to the elongation of the terminal three segments which constitute the ovipositor, it assumes a spindle shape (figs. 3, 4). The apparently visible number of segments also differs in the sexes. In the male we can count five

segments both dorsally and ventrally, with five pairs of visible abdominal spiracles, while in the female, dorsally, five main segments (just as in the male) together with three elongated tubular segments (constituting the ovipositor, described in detail later on)—five segments in all—are to be found, while ventrally there are six segments, besides the three tubular-segments, with six pairs of abdominal spiracles, the last segment, which is invisible dorsally, lying beneath the terminally visible segment of the dorsal side, so that if the segment is lifted up it can easily be seen. Thus in the female, nine segments are distinguishable. Though an exact determination of the number of abdominal segments is very difficult without embryological study, after a minute observation, it appeared to me to be rather reasonable to distinguish eleven segments in both sexes, as shown in Pl. II. figs. 8, 9 and Pl. III., figs. 1, 2, 3, 4. As can be seen from these figures, at the ventral side of the base of the abdomen, there are membranous segment-like portions, which I consider to be the first and second abdominal segments. Thus, if these two segments be added to the visible nine abdominal segments of the female, they amount to eleven segments in all. In the male, the two supposed segments being added to the five visible segments already known, and to the other modified segments that constitute the basal portion of the genitalia, also make up eleven segments in all. Regarding the details of the genital parts explanation will be found under their own headings.

*MALE GENITALIA* (Pl. II., figs. 5, 6, 7, 14; Pl. III., fig. 8, 9, 10, 11, 12, 13, 14).

The abdominal extremity of the male, in which four segments have to be discriminated, is usually concealed by the notum of the seventh segment (Pl. II., fig. 7). The sagittal plane of these four segments tends slightly to the left. Pl. III., fig. 8 shows that this was turned back to the right, as shown by the arrow,<sup>1</sup> in order to coincide with the main sagittal plane of the body. Next to the seventh abdominal segment lies a rather large cylindrical segment which I take to be the ninth segment (Pl.

1. As the figure is drawn in the ventral aspect, the arrow that shows the rightward turning may appear to indicate a leftward direction.

II., figs. 5, 6, 7). Close to the sternum of the seventh, there is a narrow chitinous bow, from the middle of which arises, towards the right, another small chitinous bow (Pl. III., fig. 8, VIII). These two chitinous bow, especially the basal larger one, I regard as the eighth segment. Near the top of the distal smaller one, another irregular chitinous piece (*c. p.*) runs backwards along the middle of the ninth segment. Posterior to the ninth segment, there is a rather small barrel-shaped segment (*x.*), provided ventrally with a pair of chitinous processes (*un.*), each having two pointed apexes. I consider this the tenth segment and call the processes the uncus, which may probably take part in copulation. Posterior to the tenth segment, usually withdrawn into that segment, there is still another smaller cylindrical segment (*xv.*) with the vertical slit-like opening of the anus. This should be the eleventh segment (figs. 6, 14). The organ which is considered as the penis is a long spiral chitinous rod (*p.*), arising from the apex of the chitinous elevation that lies on a crown-shaped area lying at the posterior end of the median ventral side of the ninth segment. The rod of the penis thence comes to the dorsal side around the right side of the ninth segment, where it curves first anteriorly then posteriorly, forming a  $\mathcal{O}$ -formed coil, turning again to the right side of the segment running more closely to the eighth segment than the coiled portion just mentioned, and finally ending in an elongate swollen apical portion. This portion is imbedded in a pocket under the eighth segment, so that it is usually invisible if it is not uncoiled (See Pl. II., fig. 5). The spiral portion of the organ consists chiefly of a dark reddish chitinous rod, lined along its one side (Pl. III., fig. 12) with a hyaline transversely striated cord. The apical swollen portion (fig. 11) is of a rather complicated structure, partly transparent and partly opaque. The apical end represents the structure of a network (fig. 13) enclosing polygonal areas. Near the apex a rather long transparent cylindrical processus arises, with many small setae on its top. The structure of the apical end of the penis seems to differ in each species. For comparison I have drawn that of *Dacus* (*Chaetodacus*) *ferrugineus dorsalis* Hendel in fig. 10, and *Dacus* (*Chaetodacus*) *bezzii* mihi in fig. 9.

*FEMALE GENITALIA—OVIPOSITOR* (Pl. II., fig. 9; Pl. III., figs. 3, 4, 5, 6, 7, 17, 18, 19).

The ninth abdominal segment in the female is in the form of a bottle upside down, into which the tenth and eleventh segments are telescoped when they are in disuse (Pl. II., fig. 9; Pl. III., fig. 4). For convenience, I call this the basal segment of the ovipositor. The tenth segment is long and cylindrical, the basal half being provided with a dorsal and a ventral pair of slender chitinous rods. The terminal half is almost entirely membranous. This can be considered as the intersegmental membrane between the tenth and eleventh segments, though I could not find any such membrane between the ninth and tenth segments (Pl. III., fig. 17). The eleventh segment (fig. 17, *XZ*), which acts as the ovipositor<sup>1</sup> is a long, slender, sharp-pointed, spear-like body, with a hard chitinous rod along the lateral side, leaving a groove between the two rods dorsally and ventrally. The apex of the ovipositor (fig. 5) is pointed like that of a spear, being provided with three projections which end in roundish tips. The length of the ovipositor, which is about 2 mm. in this species, always slightly surpasses the thickness of the rind of an orange on the day when the fly has to oviposite, so that eggs can be placed into the pulp. The end of the vagina and of the intestine also lead into the ovipositor, the course of which the writer did not succeed in tracing. For comparison I have drawn the ovipositor of *Dacus* (*Chaetodacus*) *ferrugineus dorsalis* Hendel in figs. 7 and 19, and that of *Dacus* (*Chaetodacus*) *bezzii* mihi in figs. 6 and 18.

### 3. INTERNAL STRUCTURE OF THE ADULT FLY.<sup>2</sup>

#### a. ALIMENTARY SYSTEM (Pl. IV., fig. 2).

The general structure of the alimentary canal is not essentially different from that of the house-fly. It commences anteriorly at the

1. Most entomologists call this the pseudo-ovipositor to distinguish it from the true ovipositor of Thysanura, Orthoptera, etc.

2. Of the internal structure of the fly, I have to omit the descriptions of the muscular, respiratory, circulatory and nervous systems, as all of these require further special study, and are rather far from the aim of the present investigation.

pharynx found in the proboscis. The pharynx then leads to the slender duct termed the oesophagus (*oe.*), which opens at the junction of the head and thorax into a round vesicle known as the proventriculus (*pv.*). At the spot where the oesophagus is connected with the proventriculus, a long slender duct arises, which passes through the thorax and opens into a large, transversely distended sac, termed the sucking stomach (*s. st.*) (or the crop according to HEWITT), the function of which is regarded by many authors as the food reservoir. I often experimented by giving the fly raspberry fluid,<sup>1</sup> of which it is very fond, and on dissection I found that the sucking stomach had been quickly filled with the fluid. From a certain number of flies which suddenly died in the course of breeding, I discovered the fact that the sucking stomach was enormously expanded, containing many bubbles which had probably been produced by the effect of the dissolution of excess of food.

To the proventriculus, a long, rather broad duct of almost uniform caliber leads, known as the ventriculus (*ven.*). The posterior portion of the ventriculus is much convoluted at what is termed the intestine (*int.*). The convolution of the intestine is not identical in all the specimens I have examined. The figure shows an example. The posterior portion of the intestine is slightly narrow and continues to a stout duct termed the rectum (*rec.*), which finally leads to the anus.<sup>2</sup>

The salivary gland<sup>3</sup> (*s. g.*), simple in its outer structure, is a pair of slender blind tubes. Running posteriorly through the thorax along the ventriculus, each tube reaches to the middle of the sucking stomach, where it ends, slightly dilated. Anteriorly each tube unites with the other, forming a common duct shortly after it passes into the head, whence it may possibly open into the hypopharynx, as is the case in other flies.

The Malpighian tubes (*mp. t.*) arise as paired ducts at a rather

1. Sold by the name "Ribbon Raspberry" on our market as a drink.

2. In the male, the anus opens immediately after the rectum, while in the female it is very probably opened at the end of the ovipositor, in this, however, I failed to trace its course.

3. I was unable to find more than one set of the salivary glands in the present species, although it is not certain that there are not others.



posterior point of the intestine. Each duct is shortly afterwards divided into two tubules, so that four tubules are seen in the abdominal cavity. These tubules are yellowish, moniliform, much convoluted, and are bound up with fat-bodies and with the intestine.

b. *REPRODUCTIVE SYSTEM* (Pl. IV., figs. 1, 3).

*MALE ORGANS* (fig. 3).

The male reproductive organs consist of testes, vas deferens, ejaculatory duct, ejaculatory sac and accessory glands. Each testis (*te.*) is a yellowish elongate cylindrical body, the one end, where it is more or less convoluted, being narrower than the other. From the broader end of each testis a narrow duct (vas deferens) arises, which meets a slightly broader median duct known as the ejaculatory duct. At the spot where the vasa deferentia (*v. d.*) open into the latter, many (about 16) blind tubes (*ac. g.*) are attached, possibly forming glands accessory to it. The ejaculatory duct (*e. d.*) leads to a large fleshy sac, which may be called the ejaculatory sac (*e. s.*), if I may adopt HEWITT'S nomenclature in the case of the house-fly. The ejaculatory duct may, shortly afterwards, open into the penis, but I did not succeed in tracing its course.

*FEMALE ORGANS* (fig. 1).

The female reproductive organs consist of ovaries, oviducts, spermatheca and accessory organs with their ducts, and the vagina. Each ovary (*ov.*) is roughly of spherical form, composed of many (about 30) egg-tubes, each of which contains an elongate fusiform egg when matured. Each egg bears on the apical side a massive body, which should be considered as the distal portion of the ovarian tube. Yet I could not find any serial undeveloped eggs in it.<sup>1</sup> (For the egg see p. 107). The ovarian eggs do not develop for some days<sup>2</sup> after emergence, so that the ovary is hardly visible. Even when the eggs are ripe, the size of the ovary is not so large as one might expect, as is the case with the house-

1. The observation was made during a temporary stay at Tsugumi Village, where arrangements for microscopic study were not available.

2. I examined several specimens during the three days after their emergence.

fly in which it occupies "the greater part of the abdominal cavity." On the day of the maximum emergence of flies, I dissected some examples and counted the mature eggs contained in each ovary. They are as follows :

Table I.

NUMBER OF EGGS IN THE RIGHT AND LEFT OVARIES.

Date.	Eggs in the right ovary.	Eggs in the left ovary.
Aug. 1, 1915	18	19
" "	26	10
Aug. 5, "	7	8
Aug. 7, "	22	19
" "	27	15
" "	26	28
" "	30	24
" "	23	18
" "	27	25
" "	16	28
" "	23	21
" "	31	29
" "	18	20
" "	37	29
" "	16	19

From this fact I conclude that the number of mature eggs in the right and left ovaries are not always equal. However, it has not been established whether this is due to the fact that the eggs in both ovaries do not develop simultaneously or whether mature eggs of both ovaries are differently laid, though the latter case appears to me to be more probable than the former.

From each ovary the short oviduct arises (*ov. d.*), which unite so as to form the common oviduct (*c. ov. d.*). The common oviduct

is suspended by a set of muscles where the spermathecae (*sper.*) open through the ducts, and then leads posteriorly into the vagina (*v.*). Each spermatheca is a small oviform sac with segmented appearance and a blackish centre. The spermathecae appeared to me to be two in number, as far as I could conclude from my repeated observation, although in the apple-maggot fly (*Rhagoletis pomonella* Walsh)<sup>1</sup> and in the house-fly (*Musca domestica* Linnaeus)<sup>2</sup> they are reported to be three.<sup>3</sup> From each spermatheca a winding duct arises, to which a gourd-like vesicle (*ac. o.*) is attached.<sup>4</sup> Both ducts unite into a short common duct and open into the vagina.

#### 4. EGG (Pl. IV., fig. 4).

The mature egg measures about 1.4 mm. in length and .3 mm. in width. It is of creamy white colour and fusiform in shape, obtusely rounded at one end and rather pointed at the other. At the obtuse end there are two small elevations on the egg shell as shown in the figure. The pointed end of the egg is situated proximal to the oviduct, so that when it is laid into the orange, this end goes deeper into the fruit than the other.

#### 5. STRUCTURE OF THE FULL-GROWN LARVA (Pl. V.).

##### a. EXTERNAL STRUCTURE (Pl. V., figs. 1—8).

The full-grown larva (fig. 8) is creamy white with a slight yellowish tinge. Length 12 mm. to 13 mm., width in the broadest part 3 mm. The body is long, conico-cylindrical, pointed at the anterior apex, and is made up of 12 segments.<sup>5</sup> The first segment (or cephalic segment) is trapezoidal,

1. ILLINGWORTH (16).

2. HEWITT (14).

3. In a paper (3) received during the printing of this manuscript BACK and PEMBERTON show that two spermathecae are present in the melon-fly (*Dacus cucurbitae* Coquillett) like the present species.

4. In *Rhagoletis pomonella* Walsh (16), *Musca domestica* Linnaeus (14) and *Dacus cucurbitae* Coquillett (3), there is no such vesicle attached to the duct of the spermatheca, but a pair of accessory organs which open independently into the vagina.

5. As to the number of body segments of the dipterous larva, there are many opinions. I have, therefore, for convenience, here recognized only the visible segments, although HEWITT (14) discriminated 13 segments, based on the study of the musculature.

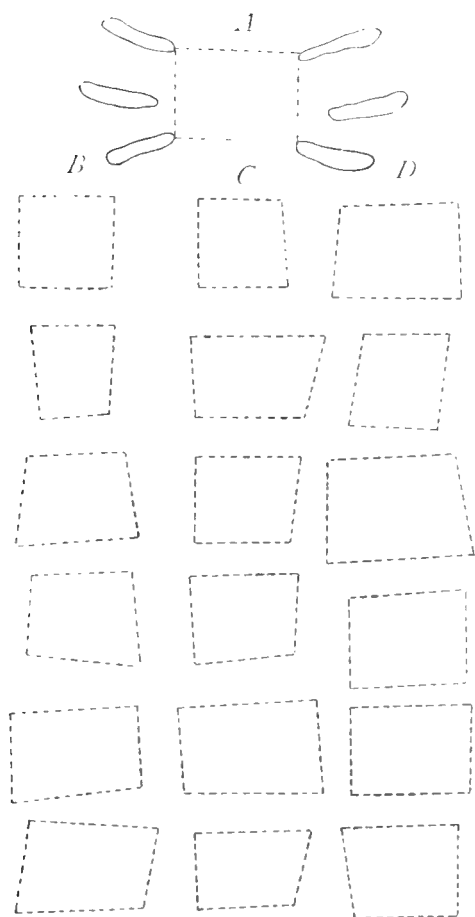
provided with two dorso-ventrally arranged conical tubercles on each side, which are known as the sensory (optic) tubercle or antennal organ (figs. 1, 2, *s. t.*). The oral lobes (*o. l.*) are the convex portions that constitute the lateral sides, which are traversed by about 17 transverse channels, the ventrally placed ones of which are distally biforked. In the middle of the oral lobes, a pair of curved testaceous hook-like bodies (*m. s.*) can be seen, respectively imbedded in a pocket specially adapted to each. They are the anterior portion of the cephalo-pharyngeal sclerites (fig. 3), and are known as the mandibular hooks or sclerites (*m. s.*). When the organ protrudes, each hook is seen to bear a cylindrical cover around its base as is shown in fig. 1. Just beneath the hooks is the entrance to the pharynx or mouth (figs. 1, 2, *mo.*), which is ventrally bounded by a tongue-like body known as the labium or lingual-like process (fig. 2, *l. p.*). The cephalo-pharyngeal sclerites (fig. 3) are of a very thick chitinous structure, situated within the anterior three segments of the larva, the anterior ends of which are the mandibular sclerites just mentioned. The general appearance of the mandibular sclerites is of a trapezoidal form, one point being produced forwards and constituting the hook already described. The posterior edge of the sclerite articulates to a rectangular piece known as the hypostomal sclerite (*h. s.*). Dorsal to it lies a thin chitinous rod, which I shall call the dorsal hypostomal sclerite (*d. h. s.*). Still posterior to the hypostomal sclerite and forming the base of the cephalo-pharyngeal sclerite, lies a large sclerite, consisting of two irregularly-shaped lateral plates united anteriorly on the median line. The dorsal portion of the anteriorly united region may be called the dorsal pharyngeal sclerite (*d. p. s.*), and the lateral portion the lateral pharyngeal sclerite (*l. p. s.*).

The second segment (fig. 8, *II.*) (the second and third segment of HEWITT) is of a conico-cylindrical form and bears laterally on the posterior border a pair of the T-shaped anterior spiracles (fig. 6), each with numerous lobes,<sup>1</sup> respectively provided with an elliptic aperture at the tip (for comparison I have drawn that of *Dacus ferrugineus dorsalis* Hendel).

1. I have counted 31 in one, and 33 each in two specimens.

The third to the last (twelfth) (fig. 8, III.—XII.) segment are usually of similar cylindrical form, gradually enlarging up to the fifth, whence to the tenth they are almost of the same diameter, but at the eleventh and twelfth slightly diminished. Near the anterior border of the ventral surface of each of the posterior eight segments there is a transverse fold furnished with many spinules, called the spiny area (*sp. a.*), which is known as the organ of locomotion. On the last segment (twelfth segment) the anus (fig. 8, *a.*, fig. 13) and the posterior spiracles are situated (fig. 7). The former is a longitudinal aperture on a raised triangular elevation situated somewhat antero-ventrally. The latter are placed rather dorsally on the posterior surface of the segment. They appear as paired elliptic chitinous plates, each of which has three transverse apertures, the middle one of which is placed slightly external to the others. Each aperture (fig. 4) is of an elongate elliptic form, guarded by the chitinous border, which bears many inwardly directed fine hairs and shows internally many partitions, owing to the presence of some chitinous rods that lie across the aperture. Around each spiracle lie five groups of radiating flat hairs (figs. 4, 7, *f. h.*), some of which are branched, each arising from a small round tubercle. In the internally placed groups, the hairs whirl around their respective tubercles.

The forms of the tetragonal figures composed by joining the internally directed apexes of the anterior and posterior apertures (the middle apertures excluded) of the posterior spiracles of both sides, are said, according to GURNEY'S statement (11, p. 26, 27), to be quite different in the larvae of different species of the fruit-flies. For example, in *Ceratitis capitata* Wiedemann, it is a transversely long rectangle, while in *Dacus tryoni* Froggatt, it is of a square form. However, as far as I could conclude from my own observations on the spiracles of many examples of the present species as well as of *Dacus ferrugineus dorsalis* Hendel, such figures never represent any definite form peculiar to each species, inasmuch as they vary considerably even in a single species. As the reader may see from text-fig. 1, in a series of examples of the present species, it is transversely rectangular, trapezoidal or sometimes even longitudinally rectangular, and similar



Text-fig. 1.

Various forms of the tetragonal figures composed by joining the apertures of the posterior spiracles :

A, Tetragonal figure of *Dacus tsunconis* Miyake, with the apertures.  $\times 62$ .

B, Tetragonal figures of *Dacus tsunconis* Miyake.  $\times 62$ .

C, Do.

D, Tetragonal figures of *Dacus ferrugineus dorsalis* Hendel.  $\times 100$ .

figures can also be observed in that of *Dacus ferrugineus dorsalis* Hendel. At the same time, I could also ascertain that such variations may not only be due to individual variation, but also to accidental effects caused by the preservation and treatment of specimens. Thus, GURNEY'S figures, though probably serviceable in the case of foreign species, are of less

importance than one might expect in the systematic determination of Japanese specimens.

b. *MUSCULAR SYSTEM* (Pl. V., fig. 10).

The muscular system of the larva of the present species is, essentially, almost similar to that of the house-fly, described and figured by HEWITT (14, p. 120) in his "House-Fly." In our species, it "consists of a segmental series of regularly repeated cutaneous muscles, forming an almost continuous sheath beneath the skin, together with a set of muscles in the anterior segments of the body which control the cephalo-pharyngeal sclerites and pharynx. In addition to this there are a set of cardiac muscles and the muscles of the alimentary tract." The muscular arrangement of the body wall is, as can be seen from Pl. V., fig. 10, in the fourth to the eleventh segments almost similar, and in the second, third and twelfth more or less modified. I here describe, as an example, the muscular arrangement of the seventh segment: The most prominent muscles are five external (*ex. d. l.*), and five internal (*in. d. l.*), dorso-lateral oblique recti-muscles. Ventral to these muscles (externally situated in the figure), there are three longitudinal ventro-lateral muscles (*l. v. l.*), and still ventral to it there are some ventral oblique muscles (*v.o.*). On the anterior and posterior borders of the segment respectively, there lies a rather stout transverse muscle known as the lateral intersegmental muscle (*l. i. m.*), each of which is connected with an oblique muscle called the internal lateral oblique muscle (*i. l. o.*). The similarity to, and the modification from, this typical arrangement in the remaining segments, may easily be seen in the figure. Between the fourth and the fifth segment, the lateral intersegmental muscles are concealed under the dorso-lateral oblique muscles, the position of which is indicated by dotted lines in the figure.

c. *RESPIRATORY SYSTEM* (Pl. V., figs. 12, 13 in part).

In the adult larva, there is a main tracheal trunk (fig. 12, *m. t. tr.*) on each side in the body, commencing anteriorly at the anterior spiracle, running longitudinally and ending posteriorly at the posterior spiracle. In

the third segment there is the anterior large tracheal commissure (*a. l. t. c.*) that connects the right and left tracheal trunks. Posterior to this is another thin commissure (*a. s. t. c.*). In the house-fly, it is said that, near the posterior spiracles, another commissure termed the posterior tracheal commissure is present, though I could not discover this in the present species. From the main tracheal trunks, many branches are sent, most of which are supplied to the border of each segment. Concerning the anterior and the posterior spiracles, explanation is already made under the heading of "external structure of the larva." The five tracheal branches arising from the brain will be described in the next chapter.

d. *NERVOUS SYSTEM* (Pl. V., fig. 11).

The central nervous system of the larva is quite different from that of larvae of other orders, as, for example, the caterpillar. While in the latter, besides the brain, there are many separated thoracic and abdominal ganglia, in the present species, they all together with the brain seem to constitute a single ganglionic mass, being themselves fused together. The mass lies between the third and fourth segment and is composed of the anteriorly situated portion, corresponding to the brain, of which the so-called "cerebral lobes"<sup>1</sup> are seen as paired spherical lobes (*c. l.*), and the posteriorly situated portion, which is a longitudinal rectangular oval body (*gl. m.*) and is known to be made by the fusion of the ganglia of the body segments. From the posterior part of the latter portion many nerves arise in pairs (I could count seven pairs, but the actual number must be still greater), each pair ending respectively at the posterior border of each segment of the fourth to the tenth segment. Besides these nerves, many pairs of fine tracheal branches also arise from the same portion, each ending respectively at the posterior border of the fifth to the eleventh segment.

e. *ALIMENTARY SYSTEM* (Pl. V., fig. 9).

The alimentary canal is much longer than the length of the body, so

1. HEWITT (14) p. 129.



that a certain portion of it is much convoluted. The foremost dilated portion is called the pharynx (*ph.*), which posteriorly narrows into a simple tube of uniform caliber known as the oesophagus (*oe.*). The oesophagus leads abruptly into a round sac termed the proventriculus (*pv.*), posteriorly from which arise four tubular blind sacs known as the caeca (*c. v.*). At the portion behind the origin of the caeca, the alimentary canal is more or less constricted and then becomes a simple tube of rather large caliber known as the ventriculus (*ven.*). The anterior portion of it is usually rather dilated and straight, while the posterior portion together with the distal portion of the alimentary canal called the intestine (*int.*) are much convoluted and twisted. From the junction of the ventriculus and the intestine, the Malpighian tubes (*m. t.*) which are paired ducts arise, each is bifurcate a short distance from the origin, convoluting and mingling with fat bodies and the alimentary canal. The tubes are moniliform in appearance and yellowish in colour. The salivary glands (*s. g.*) consist of a pair of long tubes of rather large caliber, stretching laterally and posteriorly from the fifth to the seventh segment.<sup>1</sup> From the anterior end of each tube a narrow duct arises, each of which joins anteriorly at the posterior border of the third segment (not without exception), running forward as a single median duct and opening into the pharynx on its ventral side.

Fat-bodies<sup>2</sup> consist, as in other insects, of many fat-cells, almost similar in structure to those of the adult flies. Amongst them is a pair of white glandular bodies containing white granular fluid.

#### 6. PUPA (Pl. IV., figs. 5-11).

The puparium (figs. 5-8) is elliptical in form, about 10 mm. in length and 4 mm. in width, composed of eleven segments, a little more convex on the dorsal side than on the ventral, and ochreous in colour. The anterior spiracles appear as paired crescentic tubercles on the anterior extremity (see figs. 6, 7, *a. sp.*) and the posterior spiracles appear as a paired button-like

1. In some specimens, this is not quite fixed.

2. For convenience, I append here a description of the fat-bodies.

prominence on the posterior extremity, with an external structure like that of the larval spiracles (see fig. 8, *p. sp.*). Ventral to the posterior spiracles lies a rhombic piceous shield with the median groove, which is the remnant of the anus.

As far as I could observe, until seven days after pupation there is no superficial development on the pupal body (found within the puparium), although it may appear rather soon afterwards,<sup>1</sup> as is figured in figs. 9 and 10. This state seems to be continued for quite a long time before the emergence of the fly. The pupa bears the paired knob-like processus termed the spiracular processus (fig. 10. *sp. p.*), which is destined to constitute the future thoracic spiracles, and is said in the house-fly to communicate with the external air by means of the terminal pupal spiracles between the fifth and sixth segment.

In the pupal stage the external sexual characteristics are differentiated. As in figs. 10 and 11, in the female the extremity of the abdomen is protruded into a conical tubercle, the *anlage* of the future ovipositor, while in the male, the same position is hollowed within, where in the adult the genitalia are found.

#### IV. LIFE-HISTORY AND HABITS.

##### I. TIME OF APPEARANCE.

The time of the first appearance of adult flies in the year varies according to temperature, humidity and many other conditions. Usually, however, it appears at the end of June and accelerates in emergence during July, the maximum emergence being usually reached in this month. Almost the same vigorous appearance may be seen early in August, diminishing towards the end of the month. At the beginning of September in certain localities or under some climatic conditions, the appearance is maintained to a certain extent, until it ceases entirely at the close of the month, although in warm years some flies are often still found in the month of October.

1. Unfortunately I could not ascertain the exact time it requires to make the development, though it seems to be two or three weeks after pupation.

At the first period of appearance males are far more numerous than females, while later in the season females are more prevalent. Observation on confined specimens does not differ essentially from that on those from the open field.<sup>1</sup>

## 2. LONGEVITY.

It is almost impossible to determine the longevity of the fly in the open field and the observation on confined specimens cannot be considered the same as in nature. Moreover, even in the experiments on the latter, I could not obtain satisfactory results. In my experiments at Tsugumi, of 10 males and 14 females, captured in orchards on July 24, 1914, and kept in captivity, all had died except one female by the 30th of the month although supplied with plenty of food, and the surviving female only lived until the 1st of August, the 8th day after confinement. This was far shorter than I expected, allowing for the fact that the flies lived some days before being captured. In other cases, I could keep flies alive only five days after their emergence in my breeding cage. I am satisfied that these results are not due to any lack of care in keeping the flies alive in captivity, since with the same care I repeatedly succeeded in keeping some other allied fruit-flies in the cage for over one month. Possibly the present species may become much weaker under confinement than when in the open field. Nevertheless, during captivity copulation and egg-laying were undisturbed. Putting these results and occasional out-of-door observations together I conclude that even in nature the present fly does not live longer than one month.

## 3. GENERAL BEHAVIOUR OF THE ADULT FLY.

Adults are rather sluggish and calm in habits; they usually rest on the under surface of orange-leaves, stretching out their wings obliquo-

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1. BRITAIN (6, p. 19) writes in *Rhagoletis pomonella* Walsh on the difference of the relative number of males and females, and states that opposite results are obtained from field- and cage-observations. However, he did not mention the variability of the ratio occurring in the earlier and later seasons as in the present species. BACK and PEMBERTON 3, p. 22 write that in *Dacus cucurbitae* Coquillett, the numbers in the sexes are quite evenly divided.

posteriorly as many other flies do. But when they feel themselves quite safe they extend their wings laterally, so that the axes of both wings become almost straight. When, however, they fear some danger approaching, as well as before flight, they restore their wings to the former position. When the flies are slightly disturbed, they simply remove to the neighbouring leaves or branches and occasionally return to the same spot shortly afterwards, but if they are much disturbed, they usually dart away upward or leave the place entirely, sometimes making a long flight. Flies are often seen fighting each other with their heads as weapons. This occurs not only between the same sexes but also amongst different ones. It is not seldom that the males are totally defeated in the action. The flies invariably prefer shady places,<sup>1</sup> so that we can seldom capture them on the parts of trees exposed to the sunshine. For this reason, in the invaded localities experienced orchardists capture flies at noon of a sunny day, since at that time shadows of trees are diminished to a minimum, so that the flies are naturally concentrated in a smaller area. Flies are usually found in thickly wooded places with rich foliage, and for this reason they are abundantly seen at places where old orange trees are planted thickly or other densely-leaved trees interspersed with orange-trees, but are very rarely seen in orchards where comparatively young trees are planted separately, especially where the orchards are exposed to a strong wind.

#### 4. FEEDING HABITS.

I have often observed, in the open, that flies touched with their proboscis the orange or leaf on which they were resting. Probably, in this way they feed on dew or other substances found on the surface of these objects. Especially at the time when females make punctures in oranges, many flies (mostly males) gather on these infested fruits, possibly attracted by the smell of juice that is secreted from the wounds. Whether flies are fond of the juice or not I cannot say definitely, yet they are not infrequently seen devouring it eagerly.

1. SEVERIN, H. P. writes in his interesting paper (31, p. 210) that *Epischra canadensis* Lw. also seeks shady places.

In breeding cages, during the month of August 1915 and 1916, I tried many experiments in order to test their feeding habits. I offered the flies pear, peach, plum (*Sumomo*), persimmon and water-melon, which were obtainable at that time. These were given both whole and cut, some being put at the bottom of the cage and some hanging from the top. Of these, all the whole fruits placed at the bottom of the cage were left almost untouched. The cut pieces at the bottom were eaten to a certain extent, but the pieces hanging were most attractive to the flies, for a number of them immediately gathered upon the baits as soon as they were put into the cage. Of the above mentioned fruits, the peach seemed to be most appreciated. I also gave the flies some cakes that were likewise eaten, of which the "An" (bean-jam) was most preferred. Some of the flies while feeding rested on the same spot for over half a day.

In addition, I gave the flies the liquids mentioned below, which were put into glass vessels hanging from the top of the breeding cage. The results are as follows:

(a) *Citronella Oil*. This oil is very attractive to the fly, as it is to other species, *Dacus ferrugineus* Fabricius,<sup>1</sup> *Dacus diversus* Coquillett and *Dacus zonatus* Saunders<sup>2</sup>; the results of an experiment conducted in July and in August, 1915, are tabulated below:

Table II.

EXPERIMENT WITH CITRONELLA OIL TO ATTRACT THE FLY.

Date.	Time.	Hours.	No. of flies.	No. of flies which plunged into the oil.
July 24, 1915	8 a.m.—5 p.m.	9	30	2♂
„ 26, „	1 p.m.—5 p.m.	4	24	2♀
„ 26-27 „	1 p.m.—8 a.m.	19	24	1♂, 7♀
Aug. 1, „	2 p.m.—9 p.m.	7	60	3♂, 4♀
„ 2, „	8 a.m.—12 a.m.	4	50	3♂, 3♀
„ 9, „	8 a.m.—9.5 a.m.	1.5	50	1♂, 2♀

1. FROGGATT (10).

2. HOWLETT (15).

3. I endeavoured to obtain an equal number of males and females, but this could not effectually be done.

(b) *Kerosene*. Kerosene seems not so attractive to the present species, although it is not altogether neglected. On July 26, in an experiment with 30 flies during two hours (3 p.m.—5 p.m.), one male and one female only were attracted. It is very noticeable that in this case the female was attracted. Of the Mediterranean fruit-fly females are not usually attracted by kerosene.<sup>1</sup> In a field experiment with kerosene, I fastened a shallow pan filled with kerosene to a branch of an orange-tree, both at Nakada and Seko, where flies were found in abundance. The two pans were kept there from July 28th to 30th, but no flies were caught.

(c) *Raspberry Syrup*.<sup>2</sup> This syrup is very attractive to the fly as the following results show:

Table III.

EXPERIMENT WITH RASPBERRY SYRUP TO ATTRACT THE FLY.

Date.	Time.	Hours.	No. of flies.	No. of flies which plunged into the syrup
Aug. 7	5 p.m.—6 p.m.	1	29	8 ♀
„ 8	9 p.m.—10 p.m.	1	26	3 ♂, 3 ♀
„ 9	8 p.m.—9.5 p.m.	1.5	20	3 ♀

## 5. DISPERSION.

From the results of my field observations I conclude that the present fly, like the apple-maggot fly,<sup>3</sup> seems to “remain in the immediate locality where emergence took place,” and, of course, there is no necessity for migration if there be food-supply at hand and the place is fitted for breeding. For this reason, we frequently find a considerable number of the present species in some orchards of the invaded district, even though neighbouring orchards are often comparatively free.

1. SEVERIN, H. P. and SEVERIN, H. C. (29, p. 225) (28, p. 347).

2. I used a kind of drink sold as the “Ribbon Raspberry” in the market; *vid.* p. 104.

3. O’KANE (25, p. 54); BRILLAIN (6, p. 21).

How the fruit-flies spread from the infested to the uninjured orchards is a difficult question which cannot be readily answered. However, the migration of the flies and the transportation of infected fruits should be considered as principal factors. In order to solve the former problem, a study of the flying habits of the insect is necessary. On this subject (of the fruit-flies as well as of other flies) some papers have already been published. Dr. H. H. P. SEVERIN's paper (27), possibly one of the most recent works on the subject, reports that two thousand Mediterranean fruit-flies, marked by cutting the legs through the tibial portion, were caught during one month by fifty kerosene traps at distances varying from a quarter to one and a half miles from their point of liberation. In his latest work on the currant fruit-fly (*Epochra canadensis* Loew) (31, p. 214) records the results of four experiments, of which the furthest distance that was travelled by two flies out of 150 during June 13-18, was 3290 feet. I made a similar experiment in 1915 at Tsugumi Village, where the present fruit-flies are abundant, but instead of using kerosene traps to capture the flies I had to rely on catching them by hand since kerosene is not attractive to this species. In this experiment, I utilized the days when all the fruit growers of the village are compelled by Order of the District to capture flies. At Chōkō (長幸), which is nearly the middle of the village, high and open, I liberated 102 flies which had been previously captured from orchards on the same day that the experiment was made. Holding each fly in my fingers I cut through the middle of the tibia of one of its legs with a small pair of sharp scissors. The results obtained are as follows.

Table IV.

## DISPERSION OF FLIES.

Date of experiment.	No of flies liberated.	Incision.	Weather and wind.	Date flies were captured.	Flies captured.	Probable distance from the point of liberation.					
July 27, 2.10 p.m.	26 ♂, 35 ♀	Right mid-leg cut	Weather fine with SE breeze	July 29	1 ♂	720 yards					
				Aug. 1	1 ♀		July 29, 2 p.m.	20 ♂, 21 ♀	Left mid-leg cut	Weather fine, no wind	Aug. 2
July 29, 2 p.m.	20 ♂, 21 ♀	Left mid-leg cut	Weather fine, no wind	Aug. 2	1 ♀	480 yards					
				Aug. 3	1 ♀	360 yards					

Thus the maximum distance travelled was 6 *chō*<sup>1</sup> (720 yards) and the minimum 3 *chō* (360 yards). These distances are very short, and although we cannot draw any absolute conclusions from so few experiments, yet supported by my field observations, I conclude, that our fruit-fly does not travel far, at least under normal conditions. This is of great importance in considering the control of the adult flies. Of course, if the flight is conjoined with a prevailing wind, the fly may be carried to some considerable distance, as is often the case with the house-fly.<sup>2</sup>

The Tsugumi Village, it is said that the place called Nishinouchi is the central locality where the fruit-flies made their first appearance and whence afterwards they were dispersed through two routes to adjacent places. The one route (Pl. VI., fig. 1) is over the centre of a mountain range, where the orange-orchards are extended continuously from one side to the opposite side of the mountain which belongs to Aoye Village. Formerly people of the village when working on the other side of the mountain gathered the first ripe oranges and either ate them on the spot or took them home. Naturally when they found maggots in the fruit, they threw the infested parts away. Such is the explanation given by the villagers themselves and in later years similar infested oranges have been found in the village itself.

The other route (Pl. VI., fig. 2) is rather remote from Nishinouchi. It is a mountain-pass called Motogoye, where orange-orchards are found on both sides of the mountain, so closely situated that only a short distance to the top of the mountain remains unplanted. It is said that formerly the fruit-fly infestation was only found on the Tsugumi Village side, later it spread to the opposite side. As there is a small path across that place it is more likely that people have picked infested fruits and taken them to the opposite side.

This—transportation of maggots by man—may be one of the chief factors for the fly dispersion, but we cannot exclude from our consideration the flight of the adults; probably both have contributed to the spread of the present fly injuries.

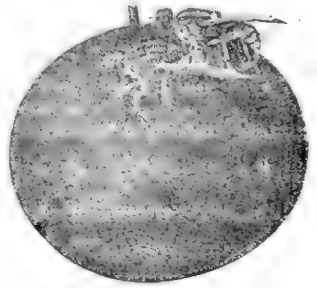
1. A *chō* = ca. 120 yards.

2. HEWITT 14, p. 74.—HODDER'S result).



## 6. COPULATION.

At copulation, the male embraces the anterior portion of the abdomen of the female, so that its head comes in contact with the hind margin of the female's scutellum. During copulation, the male draws its haustellum in and out. The paired flies often wander about in this state. The flies under copulation are often disturbed by other male, or sometimes female, flies, which swarm around them, their proboscides being used as weapons, and not infrequently another copulation is affected by the new successful rival. The duration of copulations observed by me were as follows:



Text-fig. 2.  
Copulation of *Dacus tsunensis*  
Miyake. Slightly magnified.

Table V.

DURATION OF COPULATION.

Date.	Time.	Duration.	
July 27, 1915	* 10.40 a.m.—10.54 a.m.	14 minutes	} Average 10 minutes
„ 29, „	† 7 p.m.—7.10 p.m.	10 „	
„ 29, „	† 2 p.m.—2.5 p.m.	5 „	
„ 30, „	† 8.53 p.m.—9.3 p.m.	10 „	
Aug. 1, „	† 8 a.m.—8.10 a.m.	10 „	

\* In the open.

† In confinement.

Copulation occurs at any time in the day, as is the case with the Mediterranean fruit-fly, unlike some foreign fruit-flies, such as the melon-fly (*Dacus cucurbitae* Coquillett), of which it is reported that copulation extends only from sunset to dark.<sup>1</sup> Rather frequently another male tries to copulate with a female already engaged in pairing with a male, keeping its

1. BACK and PEMBERTON (3, p. 23). In their former paper they also state the same fact.

genitalia firmly in contact with the conjugated portion of the two flies. In certain cases, the intruder calmly retains this attitude, until he finally finds out that he cannot join in the act and flies away. Two cases I have seen are as follows :

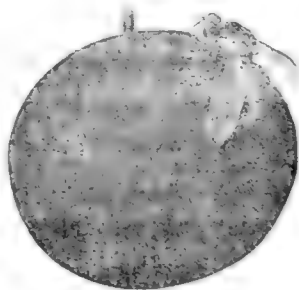
On July 31, the act lasted from 1.47 p.m to 1.51 p.m.....4 minutes

On Aug. 1,               ,               12.4 p.m to 12.7 p.m.....3 minutes

Not infrequently a female, just after pairing with a male, instantly joins with another male.<sup>1</sup> In a case observed on July 31, the former copulation lasted one minute (1.51 p.m—1.52 p.m.) and the latter 23 minutes (1.52 p.m—2.15 p.m.). When the two flies in copulation are ready to part from each other, the male dismounts from the shoulder of the female, being still connected with the latter and turns its body until the two insects' heads are directly opposite each other. The *♂*-shaped coiled organ of the male is first extended to its full length, the terminal end of which is still joined to the female's body and shortly afterwards the connection is broken.

#### 7. EGG-LAYING.

The egg-laying habits of the fly were repeatedly observed both in the open and in confinement. When a fly attempts to deposit eggs, it first runs about the surface of the fruit, as if searching for a suitable place. If the place is found, the fly extends its ovipositor full length and then bends it forward so that it makes a rather acute angle with the axis of the abdomen. The sharp point of the ovipositor is then thrust through the skin of the orange. If this is effected, the fly endeavours to penetrate deeply into the fruit, moving up and down, until the desired depth (usually, just beyond the length of the last segment of the ovipositor) is finally attained. This length is just enough to reach the pulp under the skin so that eggs are laid into juice sacs or between them, or in rare cases, between the pulp



Text-fig. 3.

Female fly laying eggs into the mandarin. Slightly magnified.

2. BACK and PLUMBERTON (3, p. 23) mention the same fact in *Dacus cucurbitae* Coquillett.

and the rind, but I have never seen them laid in the rind itself. In this respect there is a marked difference in the Mediterranean fruit-fly (*Ceratitis capitata* Wiedemann), of which it is reported that its eggs are very seldom laid in the pulp,<sup>1</sup> and in that in the few exceptions which occur because the rind of the fruit is very thin, they are "subjected to a mortality caused either by excessive moisture or lack of air."<sup>2</sup> The above stated egg-laying habit will explain why only thin-skinned oranges (mandarins and kumquarts) are infested, and thick-skinned oranges (navel oranges,<sup>3</sup> pomelos, etc.) are exempt from the attack of the present fly. And of mandarins, the so-called "*Komikan*" (smaller varieties) is subjected to the attack more severely than the *Unshiu*.

The oviposition may take only a few minutes if circumstances are quite favourable, but the time of duration is very indefinite, as in some cases the action is immediately stopped without any eggs being laid. When the laying is ended, the fly withdraws the ovipositor and walks around the puncture, cleaning the ovipositor with its hind legs. Not infrequently, the fly turns round and feeds on the juice that flows from the puncture. Very probably, the smell of the juice attracts males, because when punctures are made males are often seen to assemble there for the juice. Copulation repeatedly takes place at this time. Occasionally, a male tries to disturb a female engaged in ovipositing, and if he succeeds, copulation usually results.

#### a. EGG-PUNCTURE.

Punctures, known as the "egg-puncture," made by the ovipositor on the fruit, are very small and hardly visible to the naked eye; they are oval or circular in outline, the margin afterwards becoming whitish. The aperture is not infrequently repaired by a brownish gummy substance secreted by the orange. On examining infested oranges brought from orchards of various localities, I found that a single puncture in each fruit

1. QUAYL (26, p. 6).

2. BACK and PEMBERTON (1, p. 318).

3. It was once reported that eggs were laid into the navel oranges, but this is doubtful.

was the most frequent. Occasionally I have found fruit with two punctures, but only one fruit with three punctures and none with more. The instance of a fruit with four punctures was once reported to me. In my experiments on confined specimens, however, one or more flies would attack a single fruit repeatedly, so that those with two or three punctures were more commonly found, though fruits with a single puncture were not rare. I even found some fruits with five punctures, though I could not find any with more. Punctures are made indiscriminately in any part of the orange. The passage of the egg-puncture in the spongy-layer of rind is usually oblique.

*Number of Eggs laid in a Puncture.* As a single larva appears in each puncture, our entomologists, who have hitherto studied the present species, thought that only a single egg was laid in each puncture. However, in my breeding experiments as well as in field observations, I met no case in which a single egg was present in the puncture, though I have occasionally seen some empty punctures.<sup>1</sup> My observation at Tsugumi Village is as follows :

Table VI.

NUMBER OF EGGS IN THE PUNCTURE.

Date.	No. of eggs in each puncture.	Source of specimens.
Aug. 2, 1915	2	Field
" 3, "	2	"
" 4, "	3	"
" 4, "	4	In-door (breeding cage)
" 5, "	2	Punctures found in a single orange
" " "	4	
" " "	5	
" " "	4	
" " "	5	
" " "	5	
" 6, "	3	"
" " "	6	"

1. Recently FUKAI, Assistant in the Agricultural Institute of Ōita Prefecture, an enthusiastic observer of the present fly, told me that he had seen in one case a single egg in one puncture, although he always used to find more than one in the other cases.

As is seen from the table the maximum number of eggs found in the puncture is six and the minimum two. This differs from that of the Mediterranean fruit-fly, of which BACK and PEMBERTON (1, p. 315) describe 8-153 eggs in one puncture and FRENCH (9, p. 7) reports 5-15 eggs in each fruit.

The fly not infrequently lays eggs on the surface of the fruit, or on a leaf or twig, or occasionally on other substances. From experiments in the breeding cage, when about 30 flies were confined for a week (Aug. 1—Aug. 7), I saw that 7 batches of eggs were laid on the screen of the cage, each batch containing 1, 1, 2, 2, 3, 4 and 6 eggs respectively. As far as I could observe, all eggs that were not laid in the fruit did not hatch out.

#### b. EGG-LAYING PERIOD.

It is a known fact, that in the adults of some exotic fruit-flies the ovarian eggs require some days after emergence before they are fully matured. As for example, in the Mediterranean fruit-fly 6 to 8 days<sup>1</sup>, in the apple-maggot fly one week or less<sup>2</sup> or two weeks<sup>3</sup> are required. In my investigation on the present species I dissected some female flies in successive days after emergence (in July), and I observed that the eggs were not much developed until the 5th day. Unfortunately I could not continue the experiment further to discover when they fully develop. However, on examining many specimens captured in the open at the beginning of July, 1915, I could hardly find any which had matured eggs, whence, as is mentioned before, copulation taking place at the end of July and eggs being already laid at the beginning of August, it is very probable that our fruit-fly does not sexually mature until at least ten days after emergence. Anyhow this point requires further study.

It is noticeable that, in these flies, the number of matured eggs differs in the right and the left ovaries. Presuming that the fly oviposites at most 6 eggs in a puncture as long as the matured eggs are numerous in

1. BACK and PEMBERTON (2, p. 367).

2. O'KANE (25, p. 45).

3. ILLINGWORTH (16, p. 144).

the ovaries, it may make several punctures in succession and should lay eggs continuously in the respective punctures. However this point also requires further study.

## 8. INFESTATION OF FRUITS.

### a. *HATCHING OF EGGS.*

When the eggs are laid in the puncture, after some days they hatch. How many days they require until they hatch I do not yet know. I observed that eggs laid on Aug. 2, 1915, did not hatch until the eighth or ninth day after the deposition. In exotic species, as for example in the Mediterranean fruit-fly (*Ceratitis capitata* Wiedemann), eggs hatch in warm weather in about two days,<sup>1</sup> in the apple-maggot fly (*Rhagoletis pomonella* Walsh) in five days,<sup>2</sup> and in the currant fruit-fly (*Epochra canadensis* Loew) in 4-7 days.<sup>3</sup> Of course the length of the egg period may be variable according to local and climatic conditions.

### b. *MORTALITY OF EGGS LAID IN THE ORANGE.*

As is already stated, usually our fruit-fly lays more than one egg in a single puncture. Nevertheless, when we examine the infested orange, we always find a single larva in the carpel where a puncture has been made. We often find that an orange which bears punctures contains no larva. In a word, though the fly lays a certain number of eggs in the orange, not more than one larva ever appears in each puncture. Undoubtedly some mortality must take place among the deposited eggs of our fruit-fly as is the case in some exotic flies. This mortality of eggs has already been mentioned and discussed by many authors, *e. g.* BACK and PEMBERTON who report in detail on the Mediterranean fruit-fly (1, pp. 315-319). The cause of this mortality in our species is not clear, and as the ovipositing habits of this species differ from those of the Mediterranean fruit-fly it cannot be considered as being due to the same cause—the effect of the oil of the orange rind—as the authors describe regarding the latter

1. BACK and PEMBERTON (2, p. 373).

2. O'KANE (25, p. 60).

3. SEVERIN, II. P. (31, p. 185).

species. However, the same authors treat of the case of the Mediterranean fruit fly with the Chinese orange, in which the cause of death is attributed to excessive moisture or lack of air. In our species, it would seem that lack of air should also be considered as one of the main causes of mortality.<sup>1</sup>

c. *APPEARANCE OF LARVAE.*

The maggots appear (within fruits) usually at the beginning of October. At this time they are very small and measure about 1.5 mm. At the end of the month or the beginning of November, they are usually full grown and attain a length of about 13 mm. The larva, burying itself in the pulp, feeds on juice sacs.

d. *SYMPTOMS OF INFESTATION.*

At the season when the oviposition of the fly is made in the oranges the fruits are still unripe and look totally green. When a puncture is made on the mandarin, sooner or later (three days, according to my investigation in one case), a certain portion of the rind around the puncture becomes slightly paler than the ground colour. Day by day this pale-coloured portion becomes more and more yellowish and ochreous, stretching out gradually until it occupies a considerable area of the rind. Still later this coloured area becomes slightly reddish, usually appearing longitudinally but sometimes circularly or irregularly, along the carpel within which is the maggot. In this way, we can very easily detect the infested fruits in the invaded locality in the middle of October,<sup>2</sup> the time best fitted for recognizing injured fruits. With kumquarts the case is not alike; in that fruit, the punctured portion remains dark greenish like the ground colour, though the external area around the puncture is usually coloured yellowish as in other infested mandarin oranges. In the infested

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1. Recently SEVERIN H. P. in *Epochva canadensis* Loew, and BRITAIN in *Rhagoletis pomonella* Walsh also described the mortality of eggs, the cause of which is unknown.

2. There may be some fluctuation according to yearly climatic variations. In warmer seasons this symptom may typically appear at the end of October, while in colder seasons it may occur at the beginning of the month.

kumquart this yellowish area afterwards becomes broader but never fulvous as in the mandarin oranges.<sup>1</sup>

If we examine the pulp of the infested orange, the carpel which is affected by the maggot appears quite different from the other uninjured carpels, presenting a sooty unpleasant yellow in contrast to the bright ochreous colour of the sound carpels. The carpel in which the maggot makes its first appearance becomes shortly afterwards narrower and thinner than the other carpels. This can be seen very clearly in the cross section of the fruit (Pl. VII., figs. 1, 2, 3 Pl. VIII., figs. 1, 2). As mentioned before, a single maggot appears within each puncture, although many eggs may be laid in it and though this may be due to the mortality of the deposited eggs in some cases, yet the mortality of the newly hatched larvae must also be taken into consideration, for I have occasionally found a small dead larva in the infested carpel along with the living one. This mortality of the larvae in our species is much rarer than in the Mediterranean fruit-fly and some other exotic species, of which we are informed that this is a normal occurrence.<sup>2</sup>

By far the majority of injured mandarin oranges, which I have examined, have had only one originally infested carpel, *i.e.* the orange contains only one maggot, although the adjoining carpels may be subsequently infested by the same maggot (Pl. VII., figs. 1, 2, 3; Pl. VIII., figs. 1, 2). Instances of two originally infested carpels are not extremely rare. In this case, each infested carpel is well separated from the other<sup>3</sup> (Pl. VII., figs. 4, 5, Pl. VIII., figs. 3, 4)—usually opposite (Pl. VII., figs. 5., Pl. VIII., figs. 3). If the two maggots found in such an orange are not equally developed, the one is often much smaller than the other. Very seldom three carpels are infested (Pl. VII., figs. 6) and a case of four infested carpels has only once

1. I have, however, in 1917, in Higashi-morokata District, Miyazaki Prefecture, observed the same feature in the kumquart as in the mandarin. This might possibly be due to the varietal difference, as the former observation was made on "*Marumi*" kumquart, while the latter on "*Nagami*" kumquart.

2. The authors quoted in p. 127 have also mentioned the mortality of larvae as well as of eggs.

3. Rarely without exception. As shown in Pl. VII., fig. 9, the originally infested carpels are situated at right angles to each other.



been reported. No case of more than four infested carpels has yet been found.

The reddish yellow area of the infested oranges extends, in the later stage, wider towards the periphery and at this period (the beginning or middle of November), the entire rind of the orange itself begins to turn yellow, so that we can no longer distinguish at a glance the infested fruit from the sound. However, if we closely examine the infested orange, there is usually a more reddish tinge on the oviposited part, moreover, in the later stage, the portion around the calyx also becomes reddish. The infested orange can be also detected by the presence of the puncture, which may often be seen by the naked eye.

When the larva has nearly eaten up the contents of one carpel, in which it made its first appearance, it removes to the adjoining carpel, boring through the intermediate septa (Pl. VII., figs. 5, 6; Pl. VIII., fig. 4). Usually, until a maggot fully develops, still another and sometimes more carpels are attacked, according to the size of the fruit, the activity of the larva and to the duration of the larval period (Pl. VII., figs. 7, 8). When more carpels are infested their contents are only partly eaten. Speaking generally, if the carpel of the orange is sufficient for the nutrition of the whole larval life, only one or two carpels may be infested, although exceptions not infrequently occur. In other cases, however, as many as ten carpels may be injured as is shown below. In the kumquart, in which the sectioning is more imperfect than in the mandarin oranges, the maggot pierces the pulp quite irregularly and usually eats the seeds contained, and as the fruit is smaller I have never found in it more than one maggot (Pl. VIII., figs. 5, 6, 7, 8).

Table VII.

NUMBER OF INFESTED AND NON-INFESTED CARPELS IN AN ORANGE.

OBSERVED IN *Zemmon*, DEC. 14, 1915.

No. of oranges tested.	No. of non-infested carpels.	No. of infested carpels.	Larvae present or issued.
1	10	3	Present
2	10	3	Issued
3	9	2	"
4	10	2	"
5	8	3	"
6	9	3	"

OBSERVED IN *Komikan*, DEC. 15, 1915.

No. of oranges tested.	No. of non-infested carpels.	No. of infested carpels.	Larvae present or issued.
1	11	5	Issued
2	10	5	"
3	11	7	"
4	9	4	"
5	9	6	"
6	10	4	"
7	11	10	"
8	11	10	"
9	10	4	"
10	9	7	"

The percentage of infested fruits in a single tree is not fixed, owing to local, annual and individual differences. When the appearance of the fly is vigorous, it is often reported to amount to 40% or 50% of the total fruit of a tree. Some examples, observed by OJIMA of our Entomological Division, at Obama Village, Tamana District, Kumamoto Prefecture, are tabulated as follows :

Table VIII.

PERCENTAGE OF INFESTED FRUITS IN A SINGLE TREE.

Date.	Kind of fruit.	Total number of fruit obtained from a single tree.	No. of infested fruit.	Percentage.
Nov. 1, 1909	<i>Komikan</i>	1219	294	24%
"	"	1000	241	24%
Dec. 4, 1909	"	100 nearly	63	63%
"	"	100 nearly	6	6%
Dec. 4, 1910	"	1300 nearly	48	3.6%
"	<i>Unshiu</i>	590	21	3.5%
Dec. 21, 1910	<i>Komikan</i>	794	98	12.3%
"	<i>Unshiu</i>	522	46	8.8%

## e. EXIT OF LARVAE FROM INFESTED FRUITS.

When the larva in the orange is fully developed, sooner or later the infested fruit falls to the ground. The falling of fruits begins in the month of October and continues to November. Shortly after the fruit has fallen, the issuance of the larva takes place. This may occur within a few hours or after one day or more. Occasionally, however, larvae issue from oranges still on the tree. For this reason, infested oranges freshly picked from trees do not always bear larvae, though this may partly be due to the mortality of larvae in the fruit.<sup>1</sup> In an observation I found 8 oranges out of 10 free from larvae and in another, 69 out of 168.

In order to get out of the orange, the larva makes a rather large, circular aperture, corresponding to the thickness of its body. Usually the larva issues rather rapidly from the fruit, though not infrequently it may struggle in drawing out its body, only succeeding in coming out half way. As the time in which infested oranges fall happens to be the harvest season, all the fruits are picked and gathered for sale in the growing district, so that infested oranges are usually gathered before they fall,

1. The larva should be considered lost after death.

though some of them may drop previous to the harvest.<sup>1</sup> A great number of infested oranges were repeatedly sent to me for examination and I have observed the under-mentioned facts. Larvae seem to issue both by day and by night, but so far as I observed the issuance was more frequent in the night than in the daytime. I tabulate the observations made by Mr. FUKAI, of the Agricultural Institute of Ōita Prefecture, to whom I am much indebted for valuable assistance given me during my stay at the locality :

Table IX.

COMPARISON OF EXIT OF LARVAE BY DAY AND BY NIGHT.

Description of lot.	Date of daytime issuance.	No. of larvae issuing by day.	Date of the night issuance.	No. of larvae issuing by night.
101 mandarin oranges collected at Yukagi, Tsugumi, Oct. 23, 1915.	8 a.m., 24th—4 p.m., 24th	2	4 p.m., 23rd—8 a.m., 24th	26
	9 a.m., 26th—4 p.m., 26th	1	4 p.m., 24th—9 a.m., 25th	1
	9 a.m., 27th—4 p.m., 27th	1	2 p.m., 26th—9 a.m., 27th	0
	9 a.m., 28th—4 p.m., 28th	1	4 p.m., 26th—9 a.m., 27th	26

Larvae appear daily from harvested oranges but some immatured larvae occasionally remain very late in the fruit. I have known them remain for 20 or more days. Some examples observed by FUKAI are tabulated below :

1. At Tsugumi Village, Ōita Prefecture, fruit growers are ordered to pick up infested oranges previous to the harvest season, as soon as the first symptoms of infestation appear.

Table X.

## EXIT OF LARVAE FROM PICKED INFESTED FRUITS.

Date picked.	No. of oranges.	Date of issuance.	No. issuing.
Nov. 23, 1914	101	Nov. 24, 1914	28
		25,	2
		26,	1
		27,	28
		28,	22
		29,	1
		30,	0
		Dec. 1,	2
		2,	1
		3,	0
		4,	1
		5,	0
		6,	0
		7,	0
		8,	1
		9,	1
		10,	0
11,	2		
12,	2		
Nov. 27, 1914	163	Nov. 27, 1914	20
		28,	(Record lost)
		29,	40
		30,	3
		Dec. 1,	2
		2,	1
		3,	2
		4,	0
		5,	2
		6,	2
		7,	0
		8,	3
		9,	1
		10,	1
11,	2		
12,	2		
13,	0		
14,	4		

## f. RESISTANCE OF LARVAE.

The question as to how long the larvae can resist water or chemicals is not only interesting biologically but also very important in its relation to control measures. Speaking generally, the resistance of larvae to either sea- or fresh water is far stronger than one might presume before experiment. An experiment conducted by me is detailed below :

Table XI.

## RESISTANCE OF LARVAE TO WATER.

Date.	No. of larvae experimented upon.	Hours submerged.	Kind of water.	Living or dead.
Oct. 22, 1915, 11 a.m.—10 p.m	3	11	Sea-water	Living
„ 22,4 p.m.—23,7 a.m	15	15	„	„
„ 22,4 p.m.—23,8 a.m	15	16	„	„
„ 22,11 a.m.—23,8 a.m	3	21	„	„
„ 22,4 p.m.—23,8 a.m	9	16	„	„
Nov. 5, 1915, 3.30 p.m.—10.10 p.m	10	6.40	Well-water	„
„ 19,4 p.m.—20, 10 a.m	3	13	„	„
„	3	13	Alcohol 70%	„

In these experiments, the larvae which were brought out from the water appeared at first to be dead, but sooner or later they recovered. The temperature of the water was usually C.16°.

The larvae when put into sea- or well-water wriggle about at first and afterwards become calm. According to FUKAI'S observation, motion ceases at the end of about three and a half hours after submergence, though in reality the maggots are not weakened or killed. The time larvae take to recover from this dead appearance varies, of course, according to the length of time they have been in the water.

FUKAI<sup>1</sup> prolonged the experiment until the larvae were dead. An example is shown in table XII.:

1. Unfortunately FUKAI did not record the temperature of the water.

Table XII.<sup>1</sup>

## RESISTANCE OF LARVAE TO WATER.

1. *Experiments in Well-Water with 10 Larvae.*

Date.	12 days submerged.	14 days submerged.	23 days submerged.
Nov. 24, 1915	3 dead	6 dead	1 dead

2. *Experiments in Sea-Water with 10 Larvae.*

Date.	5 days submerged.	6 days submerged.	9 days submerged.
Nov. 24, 1915	1 dead	5 dead	4 dead

Thus larvae submerged in sea-water died after 9 days, but with well-water 23 days were required to kill them all.

FUKAI further experimented as to whether larvae, which have previously been submerged in water, can pupate.

Table XIII.

## PUPATION OF LARVAE PREVIOUSLY SUBMERGED IN WATER

(*Experiments conducted on Nov. 6, 1915, each with 5 Larvae.*)

Water used.	1 day submerged.		2 days submerged.		3 days submerged.		4 days submerged.		5 days submerged.	
	Pupated <sup>1</sup>	Dead <sup>1</sup>	Pupated	Dead	Pupated	Dead	Pupated	Dead	Pupated	Dead
Well-water	5	0	5	0	5	0	5	0	3	2
Sea-water	4	1	5	0	3	2	4	1	3	2
Lime-water	5	0	4	1	5	0	3	2	3	2

He also examined as to whether these pupae could develop into imagos.

1. The days required for pupation or until death were not recorded.

Table XIV.

## EMERGENCE OF IMAGO FROM SUBMERGED LARVAE.

*(Conditions as in Previous Experiment.)*

Water used.	1 day submerged.		2 days submerged.		3 days submerged.		4 days submerged.		5 days submerged.	
	Emerg-ed	Not	Emerg-ed	Not	Emerg-ed	Not	Emerg-ed	Not	Emerg-ed	Not
Well-water	5	0	5	0	3	2	2	3	2	1
Sea-water	3	1	5	0	1	2	4	0	0	3
Lime-water	5	0	0	4	2	3	1	2	0	3

From the above two tables one may see that the larvae can resist well-water longer than sea- or lime-water and that in the latter, pupae 5 days submerged did not develop into imagos. Though we cannot draw any positive conclusion from these experiments, it seems that if larvae are submerged over ten days in sea- or lime-water, or over 24 days in well-water,<sup>1</sup> they are almost sure to die.

Another experiment conducted by FUKAI shows that, if infested fruits that contain larvae are submerged in water, the maggots can resist still longer. FUKAI's experiment is as follows :

Table XV.

## SUBMERGENCE OF INFESTED FRUITS IN WATER DURING TEN DAYS.

*(Dec. 16—26, 1915.)*

Water used.	Fruits submerged.	Larvae contained in the fruits.	Dead or living.
Well-water	26	27	Living
Sea-water	26	29	"
Lime-water	26	29	"

He further experimented as to whether these larvae could pupate.

1. Other fresh water, such as river water etc., can be included.



Table XVI.

PUPATION OF LARVAE IN SUBMERGED INFESTED FRUITS.

Water used.	No. of larvae in infested fruits submerged.	Pupation.	Dead.
Well-water	27	3	24
Sea water	29	9	20
Lime-water	29	6	23

It will be seen that in this experiment more larvae submerged in sea-water pupated than in well-water, in which connection FUKAI suggests that the orange preserves better in sea-water than in well-water so that the larvae in the former can offer a stronger resistance than those in the latter. This, however, requires further study.

#### 9. PUPATION.

Larvae, after issuing from the fruits, crawl about on the surface of the soil for a while and then penetrate into it and begin to pupate.<sup>1</sup> I observed in 1915, that a larva which issued on Nov. 17 pupated on Nov. 23, and another issuing on Nov. 19 pupated on Nov. 22. In some cases, however, the larval stage lasts a comparatively long time (a week or more).

Pupation often takes place inside as well as outside the fruit, on the surface of the soil as well as beneath it. It is daily observed that larvae under experiment pupate easily, without burying themselves, within the vessel that contains them.

Pupation may occur from the end of November till the end of December, or, occasionally, in January of the next year. FUKAI observed in 1915 a pupation as late as Jan.° 28.

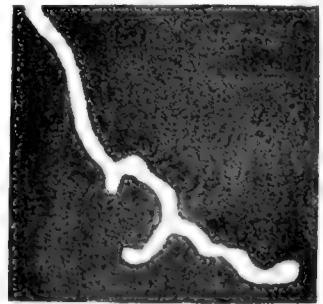
1. If circumstances are favourable they immediately bury themselves in the ground.

a. *DEPTH LARVAE PENETRATE INTO THE SOIL.*

Larvae do not penetrate deeply into the soil; usually the depth is from one to two inches. FUKAI observed that out of 128 pupae, 115 were within one inch, 11 within 2 inches and 2 within 3 inches. Usually their heads are directed towards the surface of the soil.

10. *EMERGENCE OF ADULT FLY.*

When the fly is about to emerge it pushes off with its frontal sac (ptilinum) the anterior end of the pupal case. In emergence from the pupal case a horizontal split is formed along the middle of the 4th segment, and a frontal split between the remains of the oral part and the anterior spiracular processes (See Pl. IV., figs. 5, 7, in which the line is indicated) so that, from the top of the case dorsal and ventral triangular chitinous pieces are broken off along these lines, and from the aperture thus made the new fly begins to draw out its imprisoned body. Usually, however, the dorsal triangular piece only breaks off from the pupal case, the ventral one being still attached to the case. The eclosion of the fly from the pupal case is not always easily made. If the pupa is placed on the surface of the earth (or on the bottom of any vessel), as was done in our experiments, the pupal case being unfixed the newly coming fly loses the necessary levering power to bring its body out from the puparium. This being so, of many pupae under my experiment, though some performed the eclosion completely within one hour, a few required a whole day, while some did not succeed in getting out from the puparium even after two days and were dead on the third day. The passage through which the fly comes to the surface of the earth seems, as far as I could observe, to be rather oblique and bent, as for example shown in text-fig. 4.



Text-fig. 4.  
Tunnel in the soil made by the  
fly attempting to come out (June  
1, 1916). Natural size

The fly comes to the surface of the earth by means of the inflated ptilinum of its head which it first extrudes and then draws back again, and even after coming to the surface of the earth the fly continues this action for a while. The newly emerged fly, pale in colour, bears folded wings laid on the dorsum of its body, but it has to crawl about for some time until its wings expand and its exoskeleton hardens.

OJIMA tested whether the emergence of the fly could be prevented by burying the pupae deeply into the soil, and obtained the result that burying at a depth of 1.5 feet does not kill the pupae. One of his experiments is reproduced in table XVII.

Table XVII.

## EXPERIMENTS IN BURVING PUPAE.

*100 Pupae were buried in each Section towards the End of December, 1913.*

Date of emergence.	No. of flies emerg- ed from section 1 (buried 3 inches).		No. of flies emerg- ed from section 2 (buried 5 inches).		No. of flies emerg- ed from section 3 (buried 8 inches).		No. of flies emerg- ed from section 4 (buried 1 ft).		No. of flies emerg- ed from section 5 (buried 1.5 ft).		Total.		
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Both
June 14. 1914		2											
15 "	2	3							2	2	4	2	2
16 "	2	2	1	2							3	4	7
17 "	3	5	1								4	5	9
18 "	1	1	2	3							3	4	7
20 "	1		4	6			3				5	9	14
21 "					4	2	1	1			5	3	8
22 "			2		6		4	3			12	3	15
23 "				1	1	2	2	2			1	5	6
25 "					2	1	6	6			8	7	15
26 "					1	2	1	2		1	1	3	4
27 "							5	2	2	2	7	2	9
29 "							1	1	1	1	2	2	4
Total.	9	13	10	12	13	5	18	18	5	6	55	54	109
	22		22		18		36		11		109		

## 11. LIFE-CYCLE.

From the facts above stated, we may conclude that the fly has only one brood in a year; adults appear at the end of June, accelerating in appearance during July, and in August they lay eggs. Larvae appear at the beginning of October and mature in the month of November. Pupation takes place at the end of that month or at the beginning of December, and in the pupal stage they pass the winter under ground until the adult flies appear in the early summer of the next year. The life-cycle is shown in Table XVIII.

Table XVIII.

LIFE-CYCLE OF *Dacus tsuneonis* MIYAKE.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
First year						+	+++	+++	...	---	---	...
Second year	...	...	...	...	...	..+						

12. OTHER INSECTS FOUND IN ORANGES LIKELY TO BE  
MISTAKEN FOR THE PRESENT SPECIES.

In decayed oranges, mostly in those fallen on the ground, occasionally the larvae of *Drosophila* occur (they appear to me to be more than one species). The maggot can easily be distinguished from that of the present species by its peculiar form. It is provided with a bilobed protuberance at the posterior end, on the tip of which the posterior spiracles open. Moreover, the mature maggot of the present species is far larger than the *Drosophilid* larva.

We often find on trees some pre-ripe oranges which look exactly like infested fruits of our species. The following are the chief causes for their appearance :

1. A wound on the rind, caused either accidentally or by the wind ; in these cases there is no egg-puncture.

2. Oranges and other fruits are often sucked by some Noctuid moths, such as *Ophideres tyrannus* Guenée, *Calpe excavata* Butler, etc. If these moths pierce the fruit a small puncture remains on the rind. The orange afterwards decays and falls. The puncture is smaller than the exit-hole, but larger than the egg-puncture of the present species.

3. Some Tortricids<sup>1</sup> and Pyralids (one is *Dichocrocis punctiferalis* Guenée) often bore into oranges. The boring by these insects gives oranges an appearance closely resembling fruit-fly infestation and is therefore very frequently mistaken for the injury caused by this species. Nevertheless, in the case of these Lepidoptera, the larvae that are found in the fruit bear legs peculiar to caterpillars while entrance and exit are usually made through the same aperture. Besides, the burrowing of these Lepidoptera is usually shallower than that of the fruit-fly, often not reaching to the pulp, and where the pulp is reached, only a superficial part is injured. A certain area around the hole made by these Lepidoptera is usually coloured very dark.

## V. METHODS OF CONTROL.

### I. NATURAL ENEMIES.

No parasites have been discovered up to the present, although I have paid special attention to this question. Predaceous insects, such as dragonflies and big Asylids, that are found in the locality, may possibly prey upon the flies, and I have heard from native observers that they occasionally see these insects feeding on the flies. Birds, spiders, ground-beetles and ants may, to a certain extent, take part in destroying them in their various stages, although I have no positive evidence to prove that such is the case. In 1914 and 1915, I experimented as to whether the *Bittacus*, which is known to prey upon the house-fly, might not be utilized in destroying these flies. After repeated trials, however, I discovered that none of the Bittacids would touch the fruit-flies, although under the same

1. According to OJIMA there are two kinds of Tortricids, one of which is identified as *Cacoecia pedana* Scopoli.

conditions they were very ferocious in preying on house-flies. Out of a great many specimens of fruit-fly pupae sent from Kita-kata Village, Miyazaki Prefecture, some Tachinid flies emerged, but unfortunately I was not able to make certain whether they had been parasitic upon the fruit-fly pupae or whether they had been accidentally mixed with the pupae of the fruit-flies.

## 2. CAPTURE OF ADULT FLIES.

The capture of adult flies is probably an effective measure in mitigating the fly-injuries. In Amabe District of Ōita Prefecture, fruit-growers of the invaded villages capture the adult flies, at least five times every season, by Order of the District, the flies being purchased at a price agreed upon for each particular village. According to the agreement these flies are purchased by the various local offices of the invaded villages at a price ranging from 2 *rin* to 5 *sen* each.<sup>1</sup> Thus, for example, at Aoye Village, in 1914, 78351 flies were purchased at a cost of 621.366 *yen*<sup>2</sup>, and at Tsugumi Village, 201675 flies for 1016.646 *yen*. The effect of the capture of these flies in reducing the fly-injury must not be underestimated, for in the localities where the capture of flies has been carried out strictly, the number seen has been remarkably reduced, while at distant localities where the capture has been neglected, fruit-flies were seen abundantly in the orchards during the same season.

In order to capture the adult fly, at Tsugumi Village, a special apparatus, as is shown in text-fig. 5, is used.<sup>3</sup> It is a flat oval iron-framed



Text-fig. 5.  
Apparatus used at Tsugumi Village for catching flies.  $\times \frac{1}{2}$ .

1. This difference of price is due to the numbers in which the flies abound and to other local circumstances. 1 *sen* = 10 *rin* =  $\frac{1}{10}$  *d.* Engl. money, or  $\frac{1}{10}$  *c.* U.S.A.

2. 1 *yen* = 100 *sen*.

3. This was proposed by KUBOTA, an orange-orchardist of Tsugumi Village.

hemp-yarn net of rather coarse meshes with diameters of 130 and 70 mm. This net is attached to the top of a bamboo-rod five feet long. Sometimes another rod of the same length is added to the original rod if it is desired to make the length of the handle longer. Bird-lime is applied to the net in order to capture the flies. At invaded localities of Miyazaki Prefecture simply a bamboo rod is used, with bird-lime on the top. Natives of these localities say the rod is more convenient than the Tsugumi-apparatus for use amidst thick twigs. A skilful hunter, it is said, may catch about 130 flies in a day at Tsugumi Village.

### 3. TREATMENT OF INFESTED FRUITS AND KILLING OF LARVAE AND PUPAE.

At invaded localities, infested fruits both on trees and on the ground are gathered, in order to kill the larvae contained in them. At Tsugumi Village a specially planned reservoir, made of concrete, is prepared for destroying these maggots. Infested fruits are thrown into it and lime-water is poured upon them, in order to kill the larvae. At certain localities, infested fruits are steamed or burnt by petroleum (*vid.* Pl. IX.). For this purpose infested fruits were also purchased at the local offices of several villages of Kita-amabe District. At some villages of Ōita and Kumamoto Prefectures, infested fruits are sold on the market. In the case of Kumamoto Prefecture, this sale of infested fruits was formerly even encouraged by the village authorities, since those fruits appeared ripe before the uninjured ones, so that the demand of early consumers could be met. The excuse was offered that the larvae that might issue from such fruits could not breed at the place where the oranges are eaten, provided that it is distant from the orchard, so that the fly cannot find any food-plants.

Recently it was thought that, instead of wasting infested oranges, they could be utilised as raw material for the manufacture of citric acid. Accordingly, directions for preparation were issued by the Bureau of Agriculture and this industry generally encouraged by the authorities.



For the purpose of collecting pupae from the ground at Kita-kata Village of Miyazaki Prefecture, the soil is plowed. This is not done at Tsugumi Village, since the roots of the orange-trees are covered with heaps of hay or straw. At places like Kita-kata, the use of poultry, as recommended in several foreign reports for the extermination of the exotic fruit-fly pupae, may, to a certain extent, serve as a check on the flies, so long as the orchard is not too remote from human dwellings. It is reported that poultry are used for this purpose at certain places in Miyazaki Prefecture, but I have not been informed of the results.

#### 4. OTHER MEASURES.

Screening of trees, traps, the use of attractive substances (for example—citronella oil), or poison (for example—MALLY'S fruit-fly remedy<sup>1</sup>) might probably be effective in preventing injuries, but as far as I could see, complicated circumstances in the invaded localities made all these methods most difficult to employ.

#### 5. RECOMMENDATIONS.

I would offer here the following suggestions:

1. Every effort should be made to capture adult flies early in the season of emergence when they do not oviposit in the fruit because their eggs are not yet matured.

2. Infested fruits should be gathered as quickly as possible. To do this, the first slight symptom should be detected, while the fruit is still on the tree. This may prevent the larvae escaping from the fruits; if fruits once fall, some larvae are sure to leave them and enter the ground. Moreover, unripe oranges can better be utilized as material for citric acid than ripe ones.

3. To utilise infested oranges as raw material for citric acid manufacture, since the acid is prepared from oranges by a rather simple chemical process. Thus infested oranges would be taken to a certain spot where the factory is established. In this case the reservoir to be used should be carefully equipped so as to prevent the escape of larvae.

1. Publication of the Department of Agriculture, Cape of Good Hope (7).

4. The construction of storehouses for oranges should be so improved, that if by mistake infested oranges are taken in, the larvae that issue therefrom can be collected at a certain spot where they may easily be killed. For that purpose, on one hand the floor should be firm and without intermission, so as to prevent the larvae from penetrating for pupation, and on the other hand, a certain dark spot should be left where larvae would gather on account of their phototaxis.

5. To diffuse the fullest knowledge of the present species among local orchardists, so that they may at once detect the occurrence of the insect and minimise the injury caused by this species.

## VI. DESCRIPTIONS OF NEW SPECIES BELONGING TO TRYPANEIDAE.

The author makes use of this occasion to describe 5 new species which have been discovered in the course of the present study.

### 1. *DACUS* (*CHAETODACUS*) *BEZZII*<sup>1</sup> n. sp.

(Nom. Jap. *Shima-mibai*.)

(Pl. II., fig. 2, ♀; Pl. X., fig. 2,—wing.)

? *Dacus trivittatus* Matsumura (nec Walker), (22), p. 41, pl. xxiii., fig. 9 (1916).

A medium-sized species; all the bristles are black.

Head greyish ochreous; occiput and posterior portion of the gena sprinkled with fuscous; frons with a central irregular round fuscous patch in the middle (obsolete in some specimens) and four lateral fuscous dots on each side, the anterior two of which are very closely placed. From each lateral dot the front-orbital bristle arises; vertex with a shining black transverse band including the ocellar triangle, which is also black (in some specimens this band is interrupted in the middle); a crescent-shaped

1. Dedicated to Prof. Dr. M. BEZZI of Italy, who has favoured me with most valuable advice in the course of the present study.

fuscous patch on the antennal ridge (lacking in some specimens); eyes reddish brown; clypeus yellow, shining with two round black patches; antennae ochreous, the basal two joints shining ochreous; the third joint greyish ochreous; arista black, yellow at the base; proboscis ochreous yellow, with some fuscous patches at the base of the haustellum, the palpi fuscous ochreous.

Thorax densely punctate, covered with short greyish pubescence; dorsal side greyish black, with a median  $\Lambda$ -shaped, and paired submedian, longitudinal black streaks; a median, spindle-shaped greyish-yellow spot bounded by the posterior branches of the  $\Lambda$ -shaped streak; humeral calli greyish yellow; a long lunular greyish yellow streak on each side, defined internally with black, commencing anteriorly at the transverse suture and ending at the junction of the scutellum; scutellum greyish yellow with four bristles, the apical part testaceous; (in fresh specimens all the above greyish yellow markings appear greenish yellow and this tinge often remains unchanged in some specimens); median plate of the post-scutellum black; lateral side blackish, except a large patch on the lateral plates of mesosternum and postscutellum, both of which are yellow; halteres yellow; chaetotaxy as in subgenus *Chaetodacus* Bezzi (5, p. 86) with praescutellar, and one anterior, and two posterior supra-alar bristles. Male with the second axillary lobe.

Legs ochreous; coxae testaceous; end of all the femora, base and end of all the tibiae, and distal joints of all the tarsi testaceous; upper side of the hind tibiae in most specimens with testaceous streak.

Wings hyaline; veins fuscous; the costal margin except on the costal and first costal cells narrowly bordered with brown from the pterostigma to the apex, where the brown is widened; a broad brownish suffusion on vein *Cu2.* + 1st *A.* (broader in the male specimen), filling the cubital cell with brown; a brownish suffusion along the median transverse vein.

Abdomen greyish ochreous, oval, as broad as the thorax, the first segment with the basal margin and the lateral sides bordered with black (in some specimens a triangular black patch is present in the middle); the anterior margin of the second, third and fourth segments bordered

with broad black bands ; the band of the third segment produced posteriorly into a short triangular projection in the middle ; that of the fourth segment also with a median posterior projection, which is longer than the preceding one, so that it represents a T-shaped marking ; the anterior margin of the fifth segment also with a broad piceous band, which is broken in the middle, where it is traversed by a median longitudinal band ; (in exceptions the fifth or the fourth and fifth segments bear the same T-shaped markings ; male with a row of black bristles on the sides of the posterior margin of the third segment ; female with the ovipositor rather depressed, ferrugineo-ochreous, the basal joint longer than the fifth segment.

Male. Length of body 7—8 mm.; length of wing 6—7 mm.

Female. Length of body (measured to the origin of the basal segment of the ovipositor) 9 mm. ; length of wing 8 mm.

*Local Distribution.* Oita, Miyazaki, Kagoshima and Kyoto.

*Habitat.* Kiushiu and Honshiu.

Described from 5 male and 5 female specimens taken at Tsugumi, on Aug. 28, 1915 ; besides many others examined.

Abundantly found in orange-orchards, from July to September, occasionally in November and December, but as far as I could observe the fly does not oviposit in the orange nor do adults appear from any of the maggots found in oranges, so that until positive proof has been found, the present species should not be considered as injurious to oranges, though some entomologists suppose them to be dangerous. Moreover, the species occurs in abundance in a locality where no orange trees are planted.

This species, in having three supra-alar and praescutellar bristles, and being indented on the hind margin of the wing at the end of vein *Cu2.*+1st *A.* (anal of BEZZI, 4) in the male specimen, bears the characteristics of *Chaetodacus* created by BEZZI (5, p. 86), if my conception of the genus is correct.

The present species is closely allied to *Dacus* (*Chaetodacus*) *scutellaris* Bezzi and *D.* (*C.*) *scutellatus* (Hendel). But it differs from both species

in the markings on its abdomen, so that I have described it as a probable new species in my official report on fruit-flies presented to the Imperial Department of Agriculture and Commerce in 1914. Afterwards I sent some specimens of this species to the British Museum for confirmation, whence they were sent to Prof. BEZZI of Italy who noticed that the specimens differed in many characteristics.

The species also differs from *Dacus* (*Chaetodacus*?) *trivittatus* (Walker), especially in the markings on its abdomen, if my conception of the original is correct. However, a specimen contained in the collection of the Hanazono Entomological Laboratory of Kyoto, identified as *Dacus trivittatus* by Prof. MATSUMURA of Sapporo appears to me to be no more than an example of this species. But, the species described and figured as *Dacus trivittatus* in his "Thousand Insects of Japan," Addimenta (22, p. 411, pl. xxiii., fig. 9), differs from the present species in the markings of the abdomen, since none of the abdominal bands of Matsumura's species are produced in the middle, so that the identity of the two species cannot be assumed until a closer observation has been made of the original specimen determined by Prof. MATSUMURA.

In October of last year (1917) I saw, at Tsugumi Village, a number of the flies swarming about some over-ripe persimmons on the trees.

## 2. *HYPENIDIUM POLYFASCIATUM* n. sp.

(Nom. Jap. *Sesuji-hamadara-bai*.)

(Pl. X., fig. 3,—wing.)

Body ochreous, with black streaks; all the bristles are black.

Head ochreous, with the ocellar triangle black; eyes purplish brown; face and genae whitish; antennae deeply ochreous, with the third joint rather short and rounded at the apex; arista shortly pubescent, blackish with the base ochreous; proboscis with the palpi ochreous.

Thorax above ochreous with piceous pubescence; tergal margins and humeral calli fulvous; a pair of black median streaks, ending posteriorly at

the middle of the scutum ; a pair of broader black submedian bands, interrupted at the transverse sutures ; scutellum ochreous with four very long bristles ; median plate of the postscutellum piceous black ; lateral sides and halteres pale ochreous.

Legs pale ochreous.

Wings hyaline, with the costal half fuscous black, with some pale streaks in the cells along the costa ; the posterior limit of the black area with three rounded indentations in the first second medial cell beyond vein  $M_1 + 2$ . and one indentation before the vein in the second second-medial cell ; a narrow black streak, which is continuous with the costal black area, on the median transverse vein.

Abdomen brownish ochreous, coarsely clothed with piceous pubescence ; the base of the first segment black ; second segment with a black transverse streak on each side ; third segment with a broad transverse black band, interrupted at the middle ; the fourth to the sixth segment with very broad black bands, of which the last one is slightly interrupted at the middle ; ventral side ochreous ; ovipositor with the basal segment black, the apical two segments testaceous.

Female. Length of body 6.5 mm. ; length of wing 6.5 mm.

Described from a single female specimen, taken by MITSUHASHI at Kiso-Fukushima, on July 31, 1914.

3. *ACIDIA KAGOSHIMENSIS* n. sp.

(Nom. Jap. *Kagoshima-hamadarabai*.)

(Pl. X., fig. 5,—wing.)

Prevailing colour of the body fusco-ochreous ; all the bristles are black.

Head with the occiput and the vertex fusco-ochreous, the frons yellow ; ocellar triangle black ; eyes purplish ferruginous with greenish black patches ; clypeus whitish ; genae ochreous ; antennae with the third joint bright fulvous ; arista shortly pubescent, fusco-testaceous, with the base ochreous ; proboscis with the pale ochreous palpi and brownish oral lobes.

Thorax fusco-ochreous, with very long black bristles; halteres ochreous; scutellum with four long bristles.

Legs ochreous.

Wings mostly ochreo-testaceous with hyaline pattern; costal cell and first costal cell rather pale, with two testaceous spots in the latter; pterostigma also pale, with a patch near the transverse portion of the subcosta; from the costa, external to the pterostigma to vein  $M_3 + Cu_1$ . (fifth longitudinal vein of Prof. BEZZI) broadly ochreo-testaceous; two triangular patches at the costa reaching to vein  $R_4 + 5$ .; a very small spot in the radial cell; two small elongate spots in the fifth radial cell; first second-medial cell with a long longitudinal streak near vein  $M_3 + Cu_1$ .; a short transverse streak near the median transverse vein, across vein  $M_1 + 2$ .; a large triangular patch at the posterior margin in the second second-medial cell; first cubital and anal cells hyaline, with two triangular remnants of ochreo-testaceous area in the first cubital cell on vein  $M_3 + Cu_1$ .

Abdomen shining piceous, with rather long testaceous pubescens; three basal segments with some ferruginous shades; the basal joint of the ovipositor tubular, piceous.

Female. Length of body 5.3 mm.; length of wing 5 mm.

Described from a female specimen taken by HORII at Kagoshima, on May 13, 1913.

This species is to a certain extent allied to *Acida rioxaiformis* and *Tephrella decipiens* of BEZZI, but can easily be distinguished by the difference of its wing-markings and by many other bodily characteristics.

4. *ACIDIA MARUMOI*<sup>1</sup> n. sp.

(Nom. Jap. *Takane-hamadaraibai*.)

(Pl. X., fig. 6,—wing.)

Allied to *Acidia erythraspis* Bezzi.

Prevailing colour of the body fuscous black; all the bristles are black.

Head with the vertex and the occiput fusco-fulvous; frons and genae fulvous; ocellar triangle and eyes greenish black; antennae fulvous with

1. Named after MARUMO who captured the specimen.

the arista black, shortly pubescent; proboscis with the palpi fulvo-ochreous.

Thorax fuscous black with long bristles; scutellum testaceous with four very long bristles.

Legs ochreous, with the tibiae testaceous.

Wings rather long, testaceous black with hyaline patches; costal cell hyaline, the first costal cell with a quadrate hyaline area in the middle; two triangular hyaline patches at the middle of the costal margin, reaching posteriorly to vein  $R_4+5$ ; two anteriorly-directed triangular patches at the posterior margin near the apex, one, in the fifth radial cell, rather acute, and the other in the second second-medial cell rather obtuse; a hyaline streak in the first cubital cell, the posterior half of which runs along vein  $Cu_2+1st A.$ , and the anterior half obliquely crosses the cell, thence reaching anteriorly to  $R_1$ ; anal cell entirely hyaline.

Abdomen shining black, with the ventral side piceous; male genitalia prominent, testaceous with the basal part yellow.

Male. Length of body 4.5 mm.; length of wing 4.5 mm.

Described from a single male specimen taken by MARUMO, at Kami-kōchi (5000 ft. high), Nagano Prefecture, on July 22, 1915.

Allied to *Acidia erythraspis* BEZZII, but can readily be distinguished by the difference of the wing-markings; it is very interesting that *erythraspis* was also captured at a locality 5000 ft. high. I name this species after MARUMO who captured it.

5. *GASTROZONA JAPONICA* n. sp.

(Nom. Jap. *Mitsumata-hamadara-bai*.)

(Pl. IX., fig. 4,—wing.)

Allied to *Gastrozona fasciventris* Macquart; all the bristles are black.

Head yellow, with the ocellar triangle shining black; eyes large; antennae fulvous, with the third joint rather large and rounded at the tip; arista testaceous, shortly pubescent, with the base ochreous; clypeus rather pale; (proboscis incompletely preserved).



Thorax testaceo-piceous, shining, with the humeral callosities ochreous; a pair of lunular ochreous streaks on the sides, commencing anteriorly at the transverse suture and ending posteriorly before the scutellum; scutellum yellow, the apex black, with four strong bristles; the lateral sides of the thorax ochreous, with irregular testaceous band.

Legs ochreous, with the apical portion of femora and apical joints of tarsi fuscous.

Wings hyaline, with ochreo-testaceous bands; the basal area, from the pterostigma obliquely to the cubital cell broadly ochreo-testaceous, except a certain part of the costal and the first costal cell, which are hyaline; a broad oblique band running obliquely and inwardly from the middle of the costa to the posterior portion of vein *Cu*<sub>2</sub>+1st *A.*, where the latter ends at the posterior margin; externally from the anterior end of this band to the tip of the wing, the costa is broadly margined with an ochreo-testaceous band, leaving two small long patches in cell 1*R.*; from the anterior end of the oblique band mentioned before, another band arises, running outwardly and obliquely, and ending at the posterior margin; on the median transverse vein there is another band, ending at the posterior margin.

Abdomen ochreous, with the anterior margin of the second to the fourth segments (in male) or to the fifth (in female) broadly testaceous; the fifth abdominal segment of the male ochreous yellow; the basal joint of the ovipositor very conspicuous, and longer than the last four abdominal segments taken together, flattened, ferrugineo-ochreous, with testaceous apical joint.

Male. Length of body 5 mm.; length of wing 5 mm.

Female. Length of body 7 mm., length of wing 6 mm.

Described from a male and a female specimen taken at Ōji near Tokyo May 8, 1911.

A male specimen taken at the same locality on May 5, 1902, with a median testaceous band on the thorax, is probably a varietal form.

This species is, to a certain extent, allied to *Gastrozona fasciventris*

Macquart, in having an apical black spot on the scutellum, and to *G. montana* Bezzi and *G. melanista* Bezzi, in the wing-pattern. However, from the former, it differs mainly in its wing-pattern, and from the latter in the presence of a black spot on the scutellum, and from both in the markings of the thorax and the abdomen.

## VII. SUMMARY.

1. The original home of the present species is Kiushiu and its distribution is strictly limited to that island only. It occurs evidently in Ōita, Miyazaki, Kumamoto, Kagoshima and Nagasaki Prefectures of the island, and is unreliably reported from Fukuoka Prefecture.

2. The destructiveness usually amounts to from 10% to 20% of the whole crop, but where it is severe it reaches 50%.

3. The present fly is a species hitherto unrecorded and I have therefore given it the new name *Dacus tsunconis*.

4. The present species is related in its subgeneric character to *Tridacus* Bezzi, yet it bears four supra alar bristles and for this reason the new subgenus *Tetradacus* should be created to meet cases when the subgenus is required.

5. The fly usually appears at the end of June, accelerating in emergence during July and diminishing at the end of August, but its appearance is met with until September, rarely to October. At the first period of appearance males are more numerous than females but later the reverse is the case.

6. The fly appears not to live longer than one month, as far as I could conclude both from my experiments and out-door observations.

7. The fly is usually found in shady, thickly wooded places in the orchard, so that orchards either with young trees or exposed to a strong wind are usually free from its attack.

8. In nature, the fly feeds on dew on the orange-leaf or on the juice that is secreted from punctures made by the female. In experiments, pieces of pear, peach, plum, persimmon and water-melon were eaten, of

which the peach seemed to be most appreciated. "An" (bean-jam) was also touched.

As to liquids, citronella oil and raspberry syrup are very attractive; kerosene is not attractive.

9. The fly seems to remain in the immediate locality of its emergence, so that flies may be seen in abundance at a certain place, although in the neighbourhood they are very scarce. In experiments made by liberating marked flies the maximum distance travelled was 6 *chō* (720 yards) within three days, and the minimum 3 *chō* (360 yards) within 6 days.

10. Dispersion of the fly may be caused either by the flight of the fly or by the transportation of infested fruit (*i. e.* with maggots) by men.

11. Copulation occurs at any time of the day and lasts from 5 to 14 minutes (average 10 minutes), and takes place repeatedly.

12. To lay the egg, the ovipositor, which is just long enough to reach the pulp, is penetrated into the orange so that the "egg-puncture" is made, and eggs are laid into the juice sacs or between them, or between the pulp and the rind. Thickly-skinned oranges (navel oranges, pomelos, etc.), therefore, are usually exempt from the attack of the fly, the ovipositor possibly being unable to reach the pulp. Of mandarin oranges the "*Komikan*" (smaller varieties) are attacked more severely than the *Unshiu*.

13. In nature, infested oranges each with a single puncture are most abundantly found. Oranges with two punctures are not extremely rare, but with 3 punctures they are very rare. An orange with 4 punctures was only once reported.

14. Though it is reported by our entomologists that a single egg is laid in a puncture, as far as my observation goes there are 2-6 in each puncture. The eggs are also not infrequently laid on the surface of the fruits.

15. Though I could not determine with certainty, the fly seems not to be sexually matured until at least ten days after emergence. In

specimens that I dissected, the number of matured eggs differed in the right and left ovaries.

16. I could not ascertain how long it takes the eggs to hatch, although in one case they were not hatched until the 8th day after deposition.

17. Although the fly usually lays more than one egg in a puncture only one larva afterwards appears—as is the case in the exotic species. The cause of this I have not yet discovered.

18. Maggots appear usually at the beginning of October, measuring about 1.5 mm., and at the end of that month or at the beginning of November become full grown and measure about 13 mm.

19. Oviposition is made on the unripe, green orange; when a puncture is made, a certain portion of the rind around it becomes slightly pale. Afterwards the pale area stretches out and becomes more and more yellowish until it appears slightly reddish and extends longitudinally along the carpel (sometimes irregularly), within which the maggot is. This occurs usually in the middle of October so that that is the season best fitted for recognizing infested fruit. Later the reddish area extends wider towards the periphery and the entire rind of the orange turns yellow, so that it is very hard to distinguish infested from sound fruit. However, the oviposited part and the surroundings of the calyx are noticeably reddish in the infested orange.

20. The first carpel infested by the maggot presents a sooty unpleasant colour and is usually thinner than the remaining carpels. An orange usually contains a single originally infested carpel, yet instances of two originally infested carpels (infested respectively by two maggots) are not rare. In this case the two infested carpels are usually well separated from each other. In rare cases three or four carpels are infested but no instance of more infested carpels has yet been found.

21. When the larva has nearly eaten up the contents of the originally infested carpel, it enters the adjoining carpel and thence to the next, according to the size of the fruit, activity of the larva, and the

duration of the larval period. From two to ten carpels are infested by a single maggot. In kumquarts the boring is irregular and usually the seeds are eaten.

22. When the larva in the orange is fully developed, sooner or later the infested fruit falls. This falling of oranges begins in the month of October and continues to November. Within a few hours, or in one or more days, the larva issues from the orange, making a rather large aperture in it and enters into the ground. Occasionally the larva leaves the orange while it is still on the tree. The issuance seems to occur more vigorously at night than by day.

23. The resistance of larvae both to sea- and fresh water is very strong, especially to the latter. In experiments it seemed probable that the maggot cannot survive, if it is submerged over 10 days in sea-water or over 24 days in well-water. Moreover, five days' submergence in water can prevent, to a certain extent, the pupation and emergence of adults.

24. Larvae which have issued from the fruit penetrate into the soil usually to a depth of 1 to 2 inches and pupate. Pupation occurs from the end of November till the end of December or occasionally of January of the next year.

25. The pupa pushes off, with its frontal sac, the anterior end of the pupal case and the adult fly emerges. In experiments, burying the pupa at a depth of 1.5 ft. in the soil did not kill it.

26. The life-cycle of the fly is: Adults appear at the end of June, accelerate in emergence during July, and in August lay eggs. Larvae appear at the beginning of October, attain to maturity in November, and pupate in that month or in December, passing the winter in the pupal state and appearing the next summer as adults.

27. On oranges some other insects are found likely to be mistaken for the present species. Larvae of *Drosophila* may occur in decayed oranges. Injuries caused by wind, the sucking of Noctuid moths and the boring of Tortricid and Pyralid larvae may often be mistaken as being due to the present fly.

28. As to the methods of control: No certain parasites of this fly have yet been found; dragon-flies and Asylids possibly prey upon it. Capturing adult flies by a special apparatus, collecting and treating infested fruit in order to kill larvae and picking up the pupae are practised in the infested localities. For this purpose flies and infested fruits are purchased in Ōita Prefecture by the village offices.

29. The following recommendations are offered: (1) adults should be captured as early as possible in the season of their appearance; (2) infested fruits should be picked up as quickly as possible; (3) infested oranges should be utilized as raw material for the preparation of citric acid; (4) the construction of storehouses for oranges should be improved; (5) a full knowledge of the present species should be diffused among local orchardists.

30. Descriptions of 5 new species, which were discovered during this investigation, are appended.

March, 1918.

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#### POSTSCRIPT.

I have described (though with some doubt) the number of the abdominal segments of the adult fly as eleven (*vide* p. 101), taking, besides the ordinary nine segments, two basal membranous segment-like portions into account. On further consideration, however, I have decided to withdraw this statement and recognize nine segments, since I find that it is a rather dogmatic opinion, so long as it is not based on any positive embryological or anatomical data.

Owing to the unusual delay in the printing of this paper—chiefly caused by the shortage of labour due to the Great War and the influenza epidemic—I regret to state that several papers on the fruit-flies, which appeared while this paper was in the press, could not be taken notice of.

January, 1919.

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## EXPLANATION OF PLATES

### LIST OF ABBREVIATIONS.

<i>a.</i>	Antenna.	<i>e. s.</i>	Ejaculatory sac.
<i>a. b.</i>	Apical bristle.	<i>ex. d. l.</i>	External dorso-lateral oblique recti muscle.
<i>a. c. o.</i>	Accessory organ.	<i>f.</i>	Frons.
<i>a. g.</i>	Abdominal ganglion.	<i>1st A.</i>	First Anal.
<i>al.</i>	Alula.	<i>fe.</i>	Femur.
<i>al. c.</i>	Alimentary canal.	<i>f. h.</i>	Flat hair.
<i>a. l. t. c.</i>	Anterior large tracheal commissure.	<i>f. w.</i>	Fore wing.
<i>an.</i>	Anal lobe.	<i>g.</i>	Gena.
<i>a. npl.</i>	Anterior notopleural bristle.	<i>g. l. m.</i>	Ganglionic mass.
<i>ar.</i>	Arista.	<i>g. m.</i>	Gulo-mental plate.
<i>a. r.</i>	Antennal ridge.	<i>g. s.</i>	Genal bristle
<i>a. sa.</i>	Anterior supra-alar bristle.	<i>h.</i>	Haustellum.
<i>a. sp.</i>	Anterior spiracle.	<i>hal.</i>	Halteres.
<i>a. s. t. c.</i>	Anterior small tracheal commissure.	<i>h. s.</i>	Hypostomal sclerite.
<i>a. t. s.</i>	Anterior thoracic spiracle.	<i>hu.</i>	Humeral.
<i>C.</i>	Costal cell.	<i>h. v.</i>	Humeral vein.
<i>Cr.</i>	Costa.	<i>i. c. p.</i>	Intermediate coxal plate.
<i>c.</i>	Clypeus.	<i>i. d.</i>	Imaginal disk.
<i>1C.</i>	First costal cell.	<i>i. f. o.</i>	Inferior front orbital bristle.
<i>c. a.</i>	Crown shaped area.	<i>i. l. o.</i>	Internal lateral oblique muscle.
<i>c. e.</i>	Compound eye.	<i>in. d. l.</i>	Internal dorso-lateral oblique recti muscle.
<i>c. f.</i>	Vein-like chitinied furrow.	<i>int.</i>	Intestine.
<i>ch. e.</i>	Chitinous elevation forming the base of the pen's.	<i>i. v. b.</i>	Inner vertical bristle.
<i>cl.</i>	Claw.	<i>l. ep.</i>	Labrum-epipharynx.
<i>c. l.</i>	Cerebral lobe.	<i>l. i. m.</i>	Lateral intersegmental muscle.
<i>c. p.</i>	Chitinous piece.	<i>lp.</i>	Lateral plate of mesosternum.
<i>c. p. s.</i>	Cephalo-pharyngeal skeleton.	<i>l. p. s.</i>	Lateral pharyngeal sclerite.
<i>c. r.</i>	Cephalic retractor muscles.	<i>lp. sc.</i>	Lateral plate of postscutellum
<i>Cu.</i>	Cubital cell.	<i>l. v. l.</i>	Longitudinal ventrolateral muscle.
<i>Cur.—Cu2.</i>	First—second cubital branch.	<i>M.</i>	Medial cell.
<i>1Cu.</i>	First cubital cell.	<i>m.</i>	Muscle.
<i>cx.</i>	Coxa.	<i>m (in wing).</i>	Median transverse vein.
<i>c. v.</i>	Caeca of ventriculus.	<i>M1.—M3.</i>	First—Third medial branch.
<i>d. h. s.</i>	Dorsal hypostomal sclerite.	<i>2M1.</i>	First second medial cell.
<i>d. p. s.</i>	Dorsal pharyngeal sclerite.	<i>2M2.</i>	Second second-medial cell.
<i>e.</i>	Epistomum.	<i>me. cu.</i>	Medio-cubital transverse vein.
<i>e. d.</i>	Ejaculatory duct.	<i>mo.</i>	Mouth.
<i>e. p.</i>	Epimeron.	<i>mpl.</i>	Mesopleural bristle.
<i>eps.</i>	Episternum.	<i>mp. sc.</i>	Median plate of postscutellum.
<i>ets. sp.</i>	ombined part (?) of epimeron.		

<i>ms.</i>	Mesosternum.	<i>R1.—R5.</i>	First—fifth radial branch.
<i>m. s.</i>	Maudibular sclerite.	<i>r.</i>	Rostrum.
<i>m. t.</i>	Malpighian tubes.	<i>rec.</i>	Rectum.
<i>mts.</i>	Metasternum.	<i>rm.</i>	Radio-medial transverse vein.
<i>m. t. tr.</i>	Main tracheal trunk.	<i>SC.</i>	Subcosta.
<i>mx. p.</i>	Maxillary palp.	<i>sc.</i>	Scutum of mesothorax.
<i>nv.</i>	Nerve.	<i>sep.</i>	Scapular bristle.
<i>oc.</i>	Occiput = Epicranium (HEWITT).	<i>scell.</i>	Scutellum of mesothorax.
<i>oe.</i>	Oesophagus.	<i>s. e.</i>	Simple eye.
<i>o. c.</i>	Occipital foramen.	<i>s. f. o.</i>	Supra front-orbital bristle.
<i>o. l.</i>	Oral lobe.	<i>s. g.</i>	Salivary gland.
<i>o. r.</i>	Occipital row.	<i>sp.</i>	Spiracle (Anterior thoracic).
<i>ov.</i>	Ovary.	<i>sp. a.</i>	Spiny area.
<i>o. v. b.</i>	Outer vertical bristle.	<i>sper.</i>	Spermatheca.
<i>ov. d.</i>	Oviduct.	<i>sp. p.</i>	Spiracular processus.
<i>ovip.</i>	Ovipositor.	<i>s. st.</i>	Sucking stomach.
<i>ph.</i>	Pharynx.	<i>s. t.</i>	Sensory tubercle.
<i>p. npl.</i>	Posterior notopleural bristle.	<i>st. s. st.</i>	Stalk of sucking stomach.
<i>pr. n.</i>	Pronotum.	<i>t.</i>	Tibia.
<i>prs.</i>	Praescutum (of mesothorax).	<i>tars.</i>	Tarsus.
<i>prsc.</i>	Praescutellar bristle.	<i>te.</i>	Testis.
<i>ps.</i>	Pseudo-trachea.	<i>t. g.</i>	Thoracic ganglion.
<i>p. sa.</i>	Posterior supra-alar bristle.	<i>th.</i>	Theca.
<i>p. sp.</i>	Posterior spiracle.	<i>tr.</i>	Trochanter.
<i>pt.</i>	Pterostigma.	<i>tr. b.</i>	Tracheal branch.
<i>pt. b.</i>	Pteropleural bristle.	<i>t. s.</i>	Transverse suture.
<i>pt. v.</i>	Parapteron.	<i>un.</i>	Uncus.
<i>p. t. s.</i>	Posterior thoracic spiracle.	<i>v.</i>	Vertex.
<i>pv.</i>	Proventriculus.	<i>v. d.</i>	Vas deferens
<i>pul.</i>	Pulvillus.	<i>ven.</i>	Ventriculus
<i>R.</i>	Radial cell.	<i>v. o.</i>	Ventral oblique muscle.

*1R, 3R, 5R.* First, third, fifth radial cells.

#### PLATE II.

- Fig. 1. *Dacus tsuneonis* Miyake, ♀. ×4.  
 .. 2. *Dacus bezzii* Miyake, ♀. ×4.  
 .. 3. Thorax of *Dacus tsuneonis* Miyake, lateral view. ×7.  
 .. 4. Do., showing the position of bristles. ×7.  
 .. 5. Terminal abdominal segments of male, dorso-posterior view. Magnified.  
 .. 6. Do., ventro-anterior view. Magnified.  
 .. 7. Do., lateral view. Magnified.

- Fig. 8. Abdomen of male, lateral view.  $\times 7$ .  
 „ 9. Abdomen of female, lateral view.  $\times 7$ .  
 „ 10. Head, dorsal view.  $\times 7$ .  
 „ 11. Do., dorso-anterior view.  $\times 7$ .  
 „ 12. Do., ventral view.  $\times 7$ .  
 „ 13. Thorax, dorsal view.  $\times 7$ .  
 „ 14. End of abdomen of male showing the anus, posterior view. Magnified.

## PLATE III.

- Fig. 1. Abdomen of male, dorsal view.  $\times 7$ .  
 „ 2. Do., ventral view.  $\times 7$ .  
 „ 3. Abdomen of female, dorsal view.  $\times 7$ .  
 „ 5. Do., ventral view.  $\times 7$ .  
 „ 5. Ovipositor of *Dacus tsuneonis* Miyake.  $\times 35$ .  
 „ 6. *Dacus (Chaetodacus) bezzii* Miyake.  $\times 35$ .  
 „ 7. Do. of *Dacus (Chaetodacus) ferrugineus dorsalis* Hendel.  $\times 35$ .  
 „ 8. Terminal segments of abdomen of male showing the genitalia, ventral view. (The sagittal plane of the segment is turned in the direction of the arrow, in order to make it coincide with the main sagittal plane of the body).  $\times 23$ .  
 Fig. 9. Apical portion of penis of *Dacus (Chaetodacus) bezzii* Miyake.  $\times 80$ .  
 „ 10. Apical portion of penis of *Dacus (Chaetodacus) ferrugineus dorsalis* Hendel.  $\times 80$ .  
 „ 11. Apical portion of penis of *Dacus tsuneonis* Miyake.  $\times 80$ .  
 „ 12. A part of the spiral portion of penis of do.  $\times 80$ .  
 „ 13. The network structure of the apical end of the penis.  $\times 700$ .  
 „ 14. Right wing of *Dacus tsuneonis* Miyake.  $\times 7$ .  
 „ 15. Apex of leg. Magnified.  
 „ 16. Left side legs of *Dacus tsuneonis* Miyake.  
 „ 17. Ovipositor of *Dacus tsuneonis* Miyake, with basal segments.  $\times 125$ .  
 „ 18. Do. of *Dacus (Chaetodacus) bezzii* Miyake, with basal segments.  $\times 125$ .  
 „ 19. Do. of *Dacus (C.) ferrugineus dorsalis* Hendel, with basal segments.  $\times 125$ .

## PLATE IV.

- Fig. 1. Female reproductive system.  
 „ 2. Alimentary system.  
 „ 3. Male reproductive system.  
 „ 4. Egg.  $\times 35$ .  
 „ 5. Puparium, lateral view, seen from the right side. (Dotted line indicates the position of the future split.)  $\times 5$ .  
 „ 6. Do., anterior view.  $\times 5$ .  
 „ 7. Do., dorsal view.  $\times 5$ .  
 „ 8. Do., posterior view.  $\times 5$ .  
 „ 9. Female pupa, ventral view.  $\times 6$ .  
 „ 10. Female pupa, dorsal view.  $\times 6$ .  
 „ 11. Abdominal end of male pupa, ventral view.  $\times 6$ .

## PLATE V.

- Fig. 1. Anterior end of full grown larva, anterior view.  
 „ 2. Do., ventral view.  
 „ 3. Cephalo-pharyngeal sclerite.  
 „ 4. Middle aperture of the right posterior spiracle with radiating flat hairs.  $\times 450$ .  
 „ 5. Left anterior spiracle of *Dacus* (*Chaetodacus*) *ferrugineus dorsalis* Hendel.  $\times 130$ .  
 „ 6. Left anterior spiracle of *Dacus tsunonis* Miyake.  $\times 80$ .  
 „ 7. Posterior spiracles.  $\times 80$ .  
 „ 8. Full-grown larva, lateral view.  $\times 7$ .  
 „ 9. Alimentary system of full-grown larva.  
 „ 10. Muscular system of do.  
 „ 11. Nervous system of do.  
 „ 12. Respiratory system of do.  
 „ 13. Anus with two lateral triangular elevations.  $\times 45$ .

## PLATE VI.

- Fig. 1. View of the place called Nishinouchi, which is thought to be the original locality of *Dacus tsunonis* Miyake.  $\times$  indicates the spot where the orange-orchards extend to the top of the mountain range.  
 Fig. 2. View of the mountain-pass called Motogoye, where orange orchards extend nearly to the highest point of the passage. The two white houses in front are the storehouses for oranges.  $\times$  indicates the highest point of the passage.  
 In these two photographs, the dark-looking thick woods are the old orange orchards and the streaked parts indicate young orchards.

## PLATE VII.

- Figs. 1, 2, 3. Cross-sections of mandarin oranges (the race called *Zemmon* at Tsugumi Village) each with one originally infested carpel. Natural size. Note that the infested carpel is narrower than the others. In fig. 1, the upper carpel adjoining the infested one is also partly injured.  
 Figs. 4, 5. Cross-sections of mandarin oranges (*Zemmon*), with two originally infested carpels. Natural size. Note that in fig. 4, the upper infested carpel is not narrowed as is the lower. The upper adjoining carpel of the lower infested carpel in fig. 5 is also injured and is narrowed like the latter.  
 Fig. 6. Cross-section of a mandarin orange (*Zemmon*) with three originally infested carpels. Natural size. Note that, the infested carpel on the left is not narrowed. The carpel adjoining each infested one is also partly injured.  
 Figs. 7, 8. Cross-section of mandarin orange (*Zemmon*) with one originally and many subsequently infested carpels. Natural size. Note that in fig. 7, the originally infested carpel is not narrowed. It is situated in the middle on the left.  
 Fig. 9. Cross-section of mandarin orange with two originally infested carpels. Note that these carpels are rather close to each other.

## PLATE VIII.

- Figs. 1, 2. Cross-section of mandarin orange, variety *Unshiu*, with one originally infested carpel. Natural size.
- Figs. 3, 4. Cross section of do., with two originally infested carpels. Natural size. Note that the adjoining carpels of the infested carpels in fig. 4 are also injured.
- Figs. 5, 6. Longitudinal section of kumquat (variety *Marumi*) infested by *Dacus tsuneonis* Miyake. Natural size. Note that the seeds are eaten.
- Figs. 7, 8. Cross-section of do. Natural size. Note that seeds are eaten, and in the example of fig. 8 there are crevices in the carpels, where the maggot has been burrowing, eating up the contents.

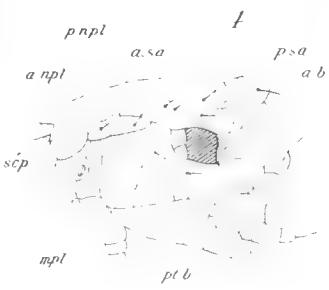
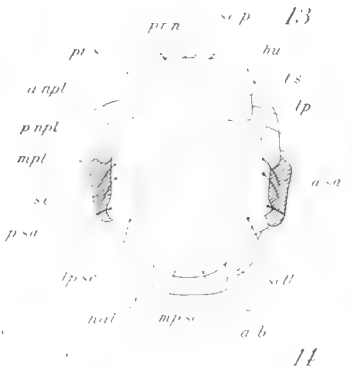
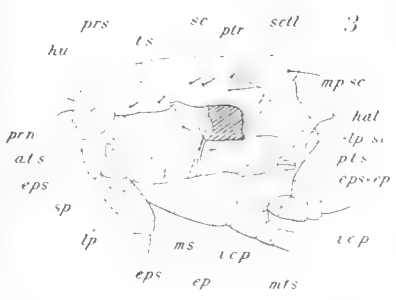
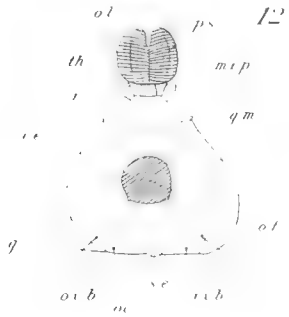
## PLATE IX.

Steaming infested oranges at Tsugumi Village, to exterminate orange-maggots.

## PLATE X.

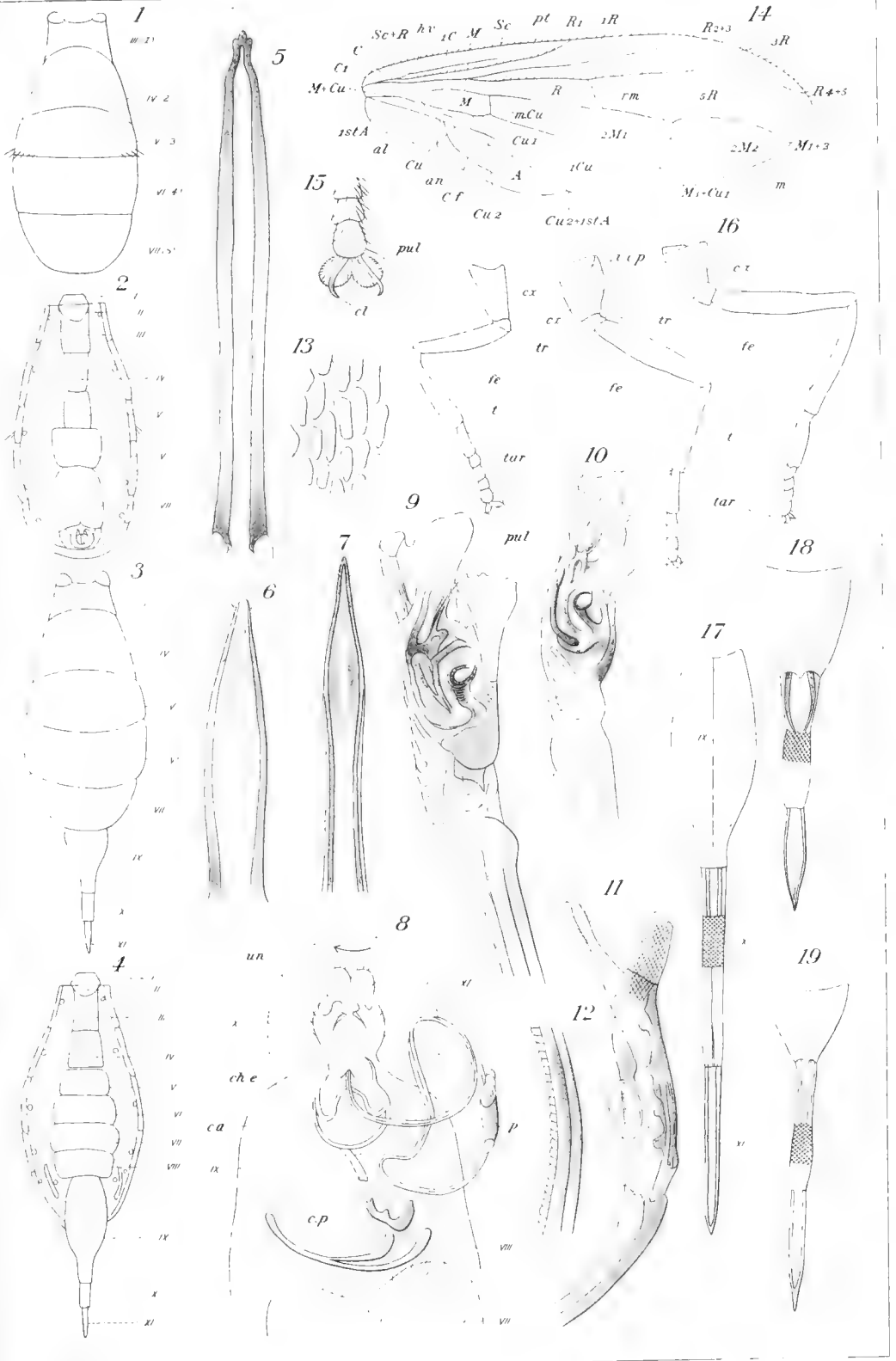
- Fig. 1. Right wing of *Dacus tsuneonis* Miyake.  $\times 9$ .
- „ 2. Do. of *Dacus (Chaetodacus) bezzii* Miyake.  $\times 12$ .
- „ 3. Do. of *Hyfenidium polyfasciatum* Miyake.  $\times 12$ .
- „ 4. Do. of *Gastrozona japonica* Miyake.  $\times 12$ .
- „ 5. Do. of *Acidtia kagoshimensis* Miyake.  $\times 12$ .
- „ 6. Do. of *A. marumoi* Miyake.  $\times 12$ .



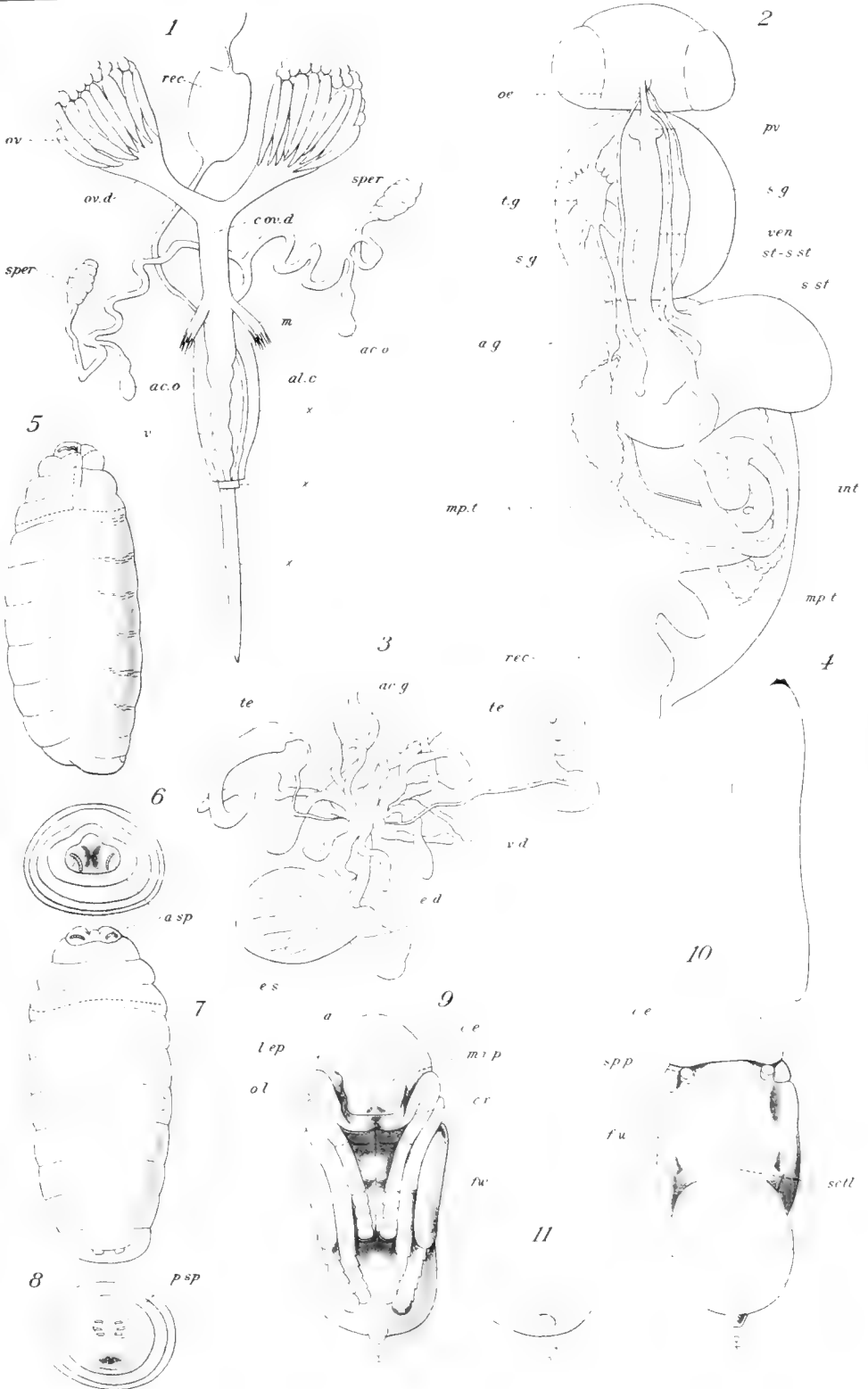




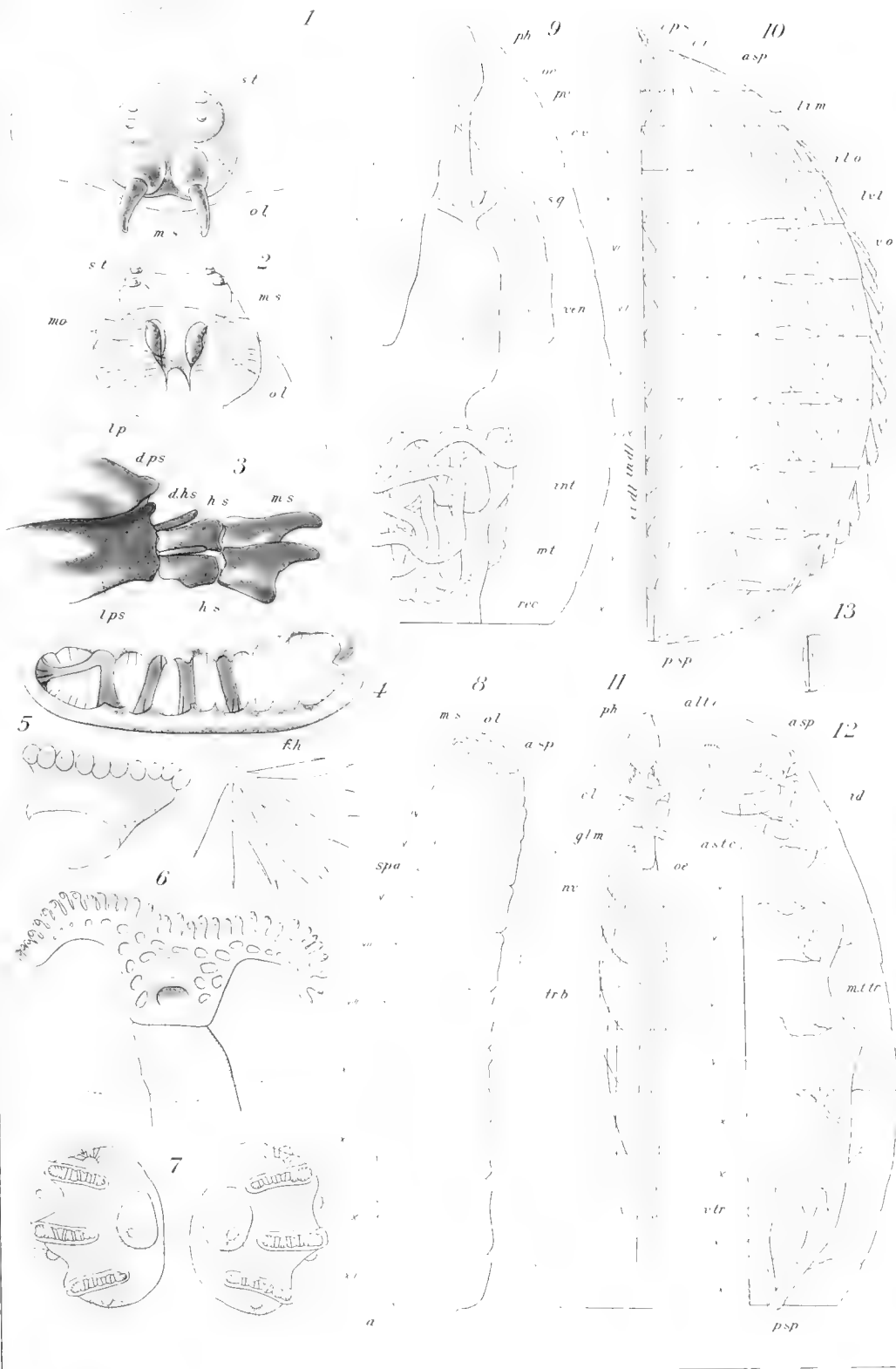














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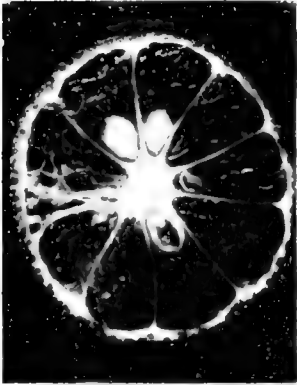


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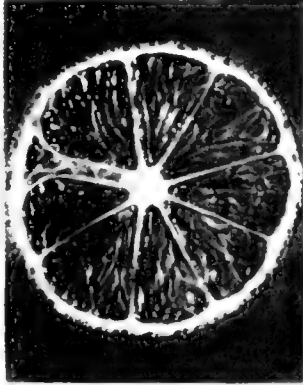




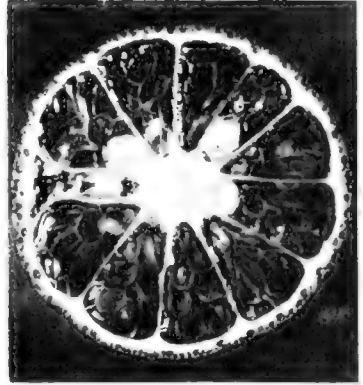
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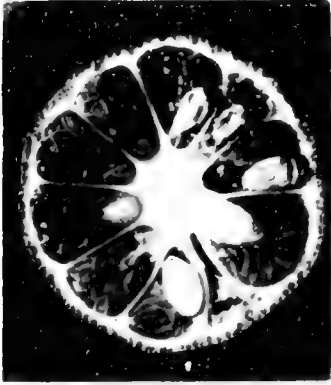
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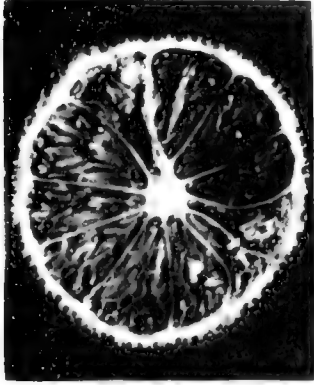
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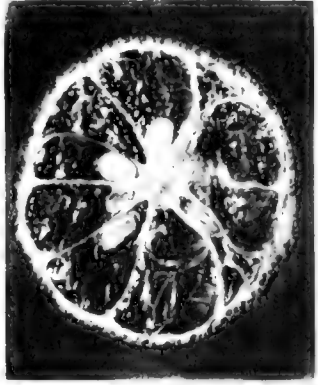
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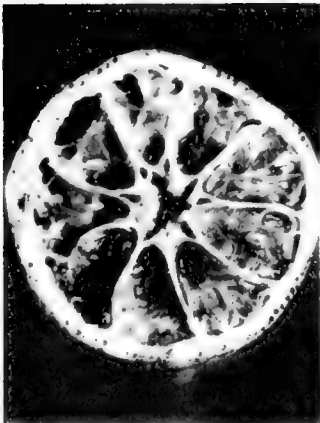
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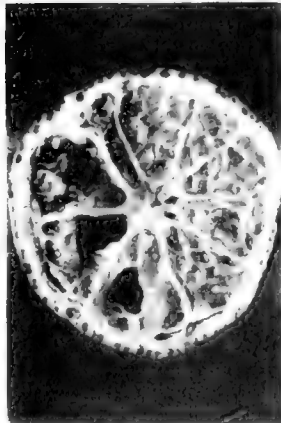
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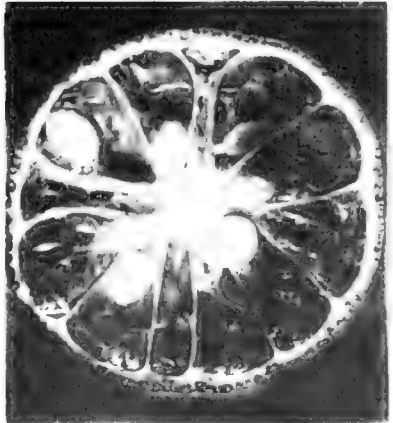
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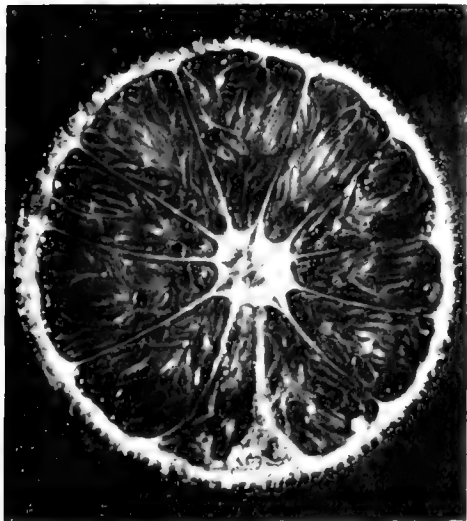
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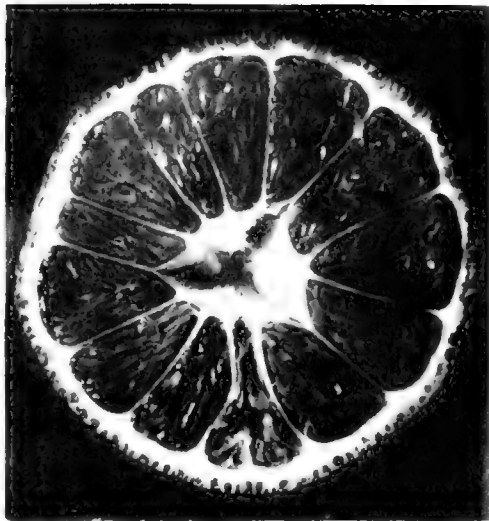
T. Miyake et B. Haginda photo



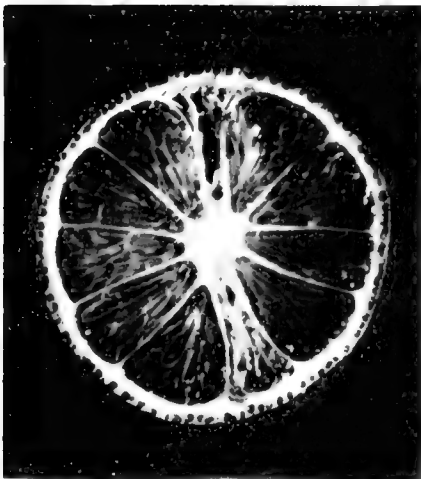
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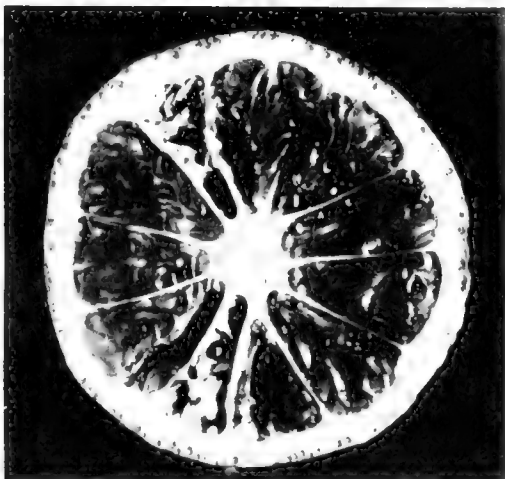
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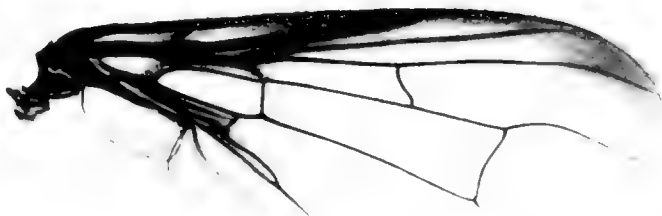




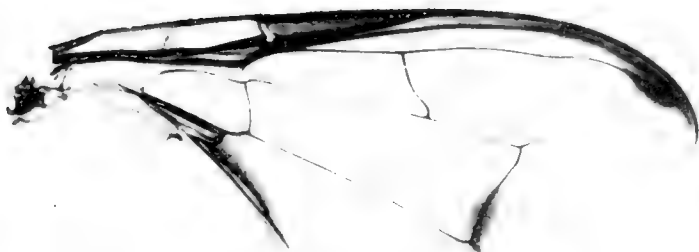
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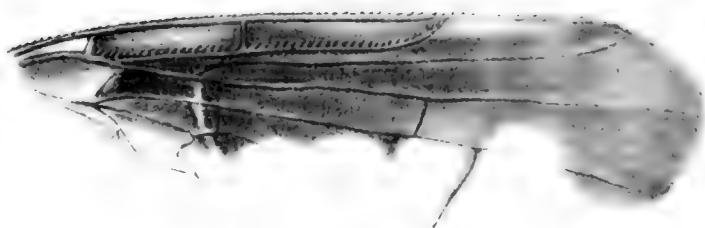
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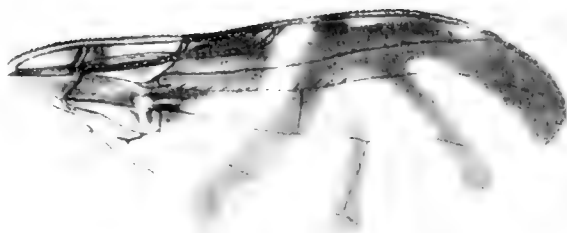
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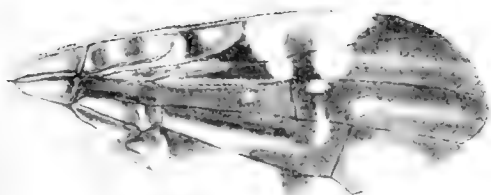
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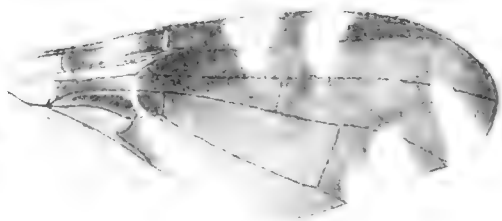
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第三卷 第一號



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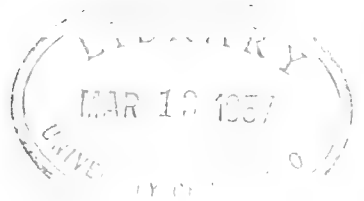
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IN

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Vol. III, No. 1



NISHIGAHARA, TOKIO

MARCH, 1924



## **Berichtigungen.**

- S. 2. Z. 16 v. o. statt (te lies : (I).
- S. 2. Z. 15 v. u. statt chemisch) lies : chemische.
- S. 11. Z. 16 v. o. statt be lies : bei.
- S. 11. Z. 17 v. o. statt angem lies : langem.
- S. 53. Z. 11 v. u. stat mmer lies : immer.









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# Über die Verdaulichkeit der Futtermittel bei Hühnern.<sup>1)</sup>

VON

T. KATAYAMA.

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Im Gegensatz zur grossen Zahl von Fütterungsversuchen, die bisher fast ausschliesslich mit grösseren landwirtschaftlichen Nutztieren, nämlich Säugetieren, ausgeführt worden sind, haben dementsprechende Untersuchungen mit Geflügel so gut wie gar keine Berücksichtigung erfahren. Man hat daher eine sehr mangelhafte Kenntnis über die Vorgänge der Verdauung, der Assimilation, und des Stoffwechsels bei Geflügel. Ferner fehlen noch wissenschaftliche Versuche in Bezug auf die Verdaulichkeit der Futtermittel, worauf die rationelle Fütterung begründet werden soll, während beim Säugetiere die verschiedenen Futtermittel nicht nur schon lange nach ihren verdaulichen Nährstoffmengen benutzt, sondern neuerdings nach ihrem Produktionswert beurteilt werden, wie dies durch die verdienstvollen Untersuchungen von *O. Kellner* und von *P. Arnsby* erreicht worden ist. Man ist daher bislang gezwungen gewesen, die Fütterung des Geflügels in der Hauptsache auf langjährige praktische Erfahrungen zu gründen, oder teilweise die beim Säugetiere erhaltenen Versuchsergebnisse anzuwenden, ohne dass man dabei exakte vergleichende Versuche mit beiden Tierarten ausführte.

Um nun die Fütterung der legenden sowie auch der wachsenden Hühner zu untersuchen, was im Vordergrund unseres Interesses steht, so ist zunächst die Feststellung der Verdaulichkeit von vielen verschiedenen Futtermitteln bei Hühnern dringend notwendig, so dass man damit ökonomische

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<sup>1)</sup> In japanischer Sprache bereits veröffentlicht in No. 42 der Berichte aus der hiesigen Landwirtschaftlichen Versuchsstation 1918.

und produktive Futtermischungen in breiter Auswahl zubereiten kann, umsomehr als bei uns in Japan das Bedürfnis nach Fleisch und Eiern immer grösser wird, so dass letztere in ziemlich grosser Menge aus China importiert werden müssen.

Eine grosse Schwierigkeit bei Verdauungsversuchen mit Geflügel liegt unter andern darin, dass der Harn direkt von den Nieren durch den Harnleiter in die Kloaka eingeführt wird und dort sich mit Kot mengt. Die Verdauungskoeffizienten der Futtermittel können daher erst in solcher Weise ermittelt werden, dass man entweder durch mechanische Operation Kot und Harn getrennt aufammelt, oder durch zweckmässige analytische Verfahren die Bestandteile der beiden Exkremeinte bestimmt.

Da allein die Rohfaser ausschliesslich im Kot, nicht aber im Harn zur Ausscheidung gelangt, so können die vermischten Exkremeinte ohne weiteres zur Bestimmung der Verdaulichkeit verwendet werden, wie dies bereits von einigen Forschern, z. B. von *H. Weiske* und *Th. Melis* (1) geschieht.

Was die anderen Nährstoffe betrifft, so sind von *I. Kalugin* (2), *W. von Knieriem* (3), *E. W. Brown* (4), *J. M. Bartlett* (5) besondere chemisch Verfahren vorgeschlagen worden, indem sie glaubten, die Verdauungskoeffizienten dadurch ohne erheblichen Fehler berechnen zu können, dass man allein Harnsäure und Ammoniak in den Exkrementen berücksichtigte, weil diese Stickstoffsubstanzen in dem normalen Harn der Geflügel als hauptsächliche Bestandteile enthalten sind, während die in Äther löslichen Stoffe nur sehr wenig, und stickstofffreie Extraktstoffe auch nicht so viel sein können. Aber es ist nun sehr notwendig, über die Frage Auskunft zu geben, ob die Fehlergrenze bei diesen Verfahren tatsächlich unbedeutend klein ist.

Von anderer Seite haben *S. Paraschtschuk* (6), *F. Lehmann* (7), *W. Völtz* und *G. Yakuwa* (8) anus practernaturalis bei Hühnern angelegt und somit Harn und Kot getrennt gesammelt. Obwohl dieses Operationsverfahren keine Störung auf die Verdauungsversuche ausübt, ist es jedoch sehr umständlich, dass man in jedem Falle eine geübte Technik braucht, wenn

man irgend ein Futtermittel auf die Verdaulichkeit hin untersuchen will, und es ist klar, dass man dies unter normalen Verhältnissen nicht kann.

Um Beiträge zur Ausfüllung der eben erwähnten Lücken zu liefern, wurden unsere Versuche, die von 1911–1913 dauerten, in folgender Weise eingerichtet.

## I. PLAN UND METHODE DER VORLIEGENDEN UNTERSUCHUNGEN.

Zuerst wurden die Fütterungsversuche mit Hühnern im normalen Zustande ausgeführt, indem man dabei die Exkremeute sammelte. Danach wurden an denselben Hühnern anus praeternaturalis angelegt und somit die Verdaulichkeit derselben Futtermittel festgestellt, welche in vorangegangenen Versuchen benutzt worden waren. Dann waren wir bestrebt, diejenigen Verfahren durch die Untersuchungen über die dabei gesammelten Harnproben zu finden, durch welche man die Bestandteile der Harnteile in den vermischten Exkrementen quantitativ bestimmen kann. Diese Verfahren wurden nun an den in vorangegangenen Versuchsreihen von normalen Hühnern erhaltenen Exkrementen angewandt. Endlich wurde die Vergleichung unternommen, die Frage zu beantworten, ob die so erhaltenen Verdauungskoeffizienten mit den entsprechenden bei operierten Hühnern genau genug übereinstimmen.

Zu diesem Zwecke habe ich als Versuchstiere 2 zweijährige mittel-grosse Hähne der Landrasse, bezeichnet Nr. 22 und Nr. 24, aus mehreren ausgewählt, die aus der Umgegend beschafft wurden und die zuerst an den Aufenthalt im Stoffwechselstälchen gewöhnt werden mussten. Letzteres ist ein Zinkdrahtnetz Käfig, der 55 cm hoch, 40 cm breit und 67 cm lang ist und eine Sitzstange in der Mitte hat. Ausserhalb der Vorderwand wird ein grösseres Zinkblechkästchen mit Futter so fixiert, dass das Huhn bei der Futteraufnahme den Kopf durch eine entsprechende Öffnung im Kästchen durchstecken muss, und somit das Herauswerfen von Futter verhindert wird. Die Grösse des Käfigs gestattet dem Huhn genügend freie Bewegung, sodass man nicht zu befürchten braucht, dass es durch

aine lange Zwanglage in seinem Befinden gestört wird und deswegen ein anormales Verhalten stattfindet. Der Käfig steht auf einem als Boden dienenden Zinkrost, dessen Stäbe etwa 0.6 cm Durchmesser haben und etwa 1.8 cm von einander entfernt sind, durch welches die vom Versuchstiere entleerten Exkremeute leicht hindurch fallen können. Der Rost liegt auf einem festen verzinkten eisernen vierfüßigen Stand. Unter dem Rost befindet sich ein ausziehbarer Zinkblechkasten, mit einer passend grossen, etwa 0.75 cm dicken Glasplatte eingelegt. Die Platte ist am Rande herum mit einer Rinne versehen, welche 4 cm breit und nach dem Rande tief geschiefert (ca. 0.25 cm tief) ist, wodurch der geringste Verlust von Waschwasser vermieden werden kann.

Nachdem die 4-bis 6-tägige Verfütterung vollendet war, wurde am Morgen früh die Waschung der Stäbe und der Glasplatte vorgenommen und der eigentliche Versuch begonnen, der 7 bis 10 Tage dauerte. Die geringe Menge Exkremeute, welche auf dem Zinkstab haften bleibt, wird mehreremale alle Tage mittels kleiner Spatel fallen gelassen, mit Wasser ausgespült, und somit werden die Füße der Versuchstiere nur sehr selten beschmutzt. Die auf die Glasplatte gefallenen Exkremeute werden in eine Porzellanschale aufgenommen, indem man dabei mit einer passenden breiten dünnen Spatel schaufelt und mit Wasser abwäscht.

Mehrere Versuche verliefen in dieser Weise glatt. Von der 6. Periode ab habe ich deshalb an die Tiere einen Sammel-Apparat für die Exkremeute angebracht, weil sie nach der Operation gezwungen werden, solches Geschirr zu tragen. *Paraschuk* und *Vetz* verwendeten zu diesem Zweck Gummibeutel, und *Brown* Aluminium-Pfannen sowie gummierten Tuchbeutel. Ich habe aber nach einigen Versuchen ein Kästchen angenommen, welches aus einem sehr dünnen Nickelblech besteht, und etwa 300 ccm fasst. Jeden Tag wurde dasselbe durch ein anderes ersetzt, was sehr leicht durchführbar war, weil es nur mittelst 2 Häkchen und 2 Schlingen bei genauer Anpassung an dem zugehörigen Drahringe angehakt war, welcher den Schwanzrumpf sowie die Kloaka umgibt, und mit Leinenstreifen an den Körper befestigt.

Das Futter, welches mit Wasser bebrüht war, wurde von den Tieren

3 mal täglich verzehrt, stets vollständig mit guter Fresslust. Die geringe Menge Futterteile, welche zuweilen trotz oben geschilderter Vorrichtungen aus dem Schnabel vor die Füße hinfallen, werden auf einem gerade unter dem Rost angebrachten Metallblechtische aufgenommen und wiederum in den Futterkasten zurückgetan. Die Tiere erhielten immer Wasser ad libitum, das sich in der Seitenwand befindet, und in den Pausen zwischen den Perioden genügende Menge getrocknetes Spinatmehl sowie Quarzsand von etwa Erbsengröße. Der Kies wurde aber sehr oft einige Tage nach dem Verschlucken wiederum in den Exkrementen ausgeschieden und er konnte den Tieren deswegen nicht mehr unentbehrlich sein, weil die Futterkörner sowie andere feste Futtermittel stets in geschrotetem oder gemahlenem Zustande vorgelegt wurden. Um einerseits diesen groben Kies aus Analysierproben zu entfernen, anderseits Kot und Harn gut durchzumengen, wurden die Exkremente auf der Glasplatte mit einem Spatel von dünnem Metallblech maceriert und der dabei gefundene Kies aufgelesen und mit Wasser abgewaschen, bevor sie herausgezogen wurden. Die Exkremente wurden zusammen mit dem Waschwasser in eine Porzellanschale aufgenommen, bei 55–60°C getrocknet, dann zur Analyse gemahlen.

Eine Anzahl von Fütterungsversuchen, nämlich 15 Perioden, wurden während August 1911 bis März 1912 ausgeführt, indem dabei Weizen Gerste, Reisfuttermehl, Weizenkleie, getrocknete Flussfische, Fischguano, geschälter und ungeschälter Reis, getrocknetes Gemüsemehl, Kleeheu, Süsskartoffelpülpe, Sojabohnenkuchen als Futter benutzt wurden. Die Futtermittel, wie z.B. Gemüse, Fischmehl, Kartoffelpülpe, Sojabohnenkuchen, welche gewöhnlich als Beifutter verwendet werden, wurden gleichzeitig dem anderen Grundfutter zugelegt.

Die Menge des Futters und der Durchschnittswert für die Exkremente deren an einzelnen Tagen in jeder Periode erlangte Zahlen, in der im Anhang befindlichen Tabelle zusammengestellt, waren folgende :

## Erste Fütterungsversuchsreihe.

	Futter	Hahn Nr. 22 Exkreme lufttrocken g	Hahn Nr. 24 Exkreme lufttrocken g
1. Periode	60 g Weizen ... ..	14.59	14.01
2. „	40 g Weizen, 50 g getrocknete Gemüse... ..	19.89	19.60
3. „	60 g Weizen ... ..	15.10	14.74
4. „	70 g Gerste ... ..	20.89	20.40
5. „	40 g Gerste, 30 g Reisuftermehl (Nr. 1) ... ..	41.33	39.35
6. „	40 g Gerste, 30 g Fischguano ...	27.11	26.84
7. „	40 g Gerste, 30 g getrocknete Fische	28.47	27.30
8. „	13.33 g Gerste, 10 g getrocknete Fische, 50 g getrockn. Süßkartoffelpülpe ... ..	26.60	26.70
9. „	70 g Gerste ... ..	21.45	21.19
10. „	60 g ungeschälter Reis ... ..	17.65	19.45
11. „	70 g Gerste ... ..	24.42	23.82
12. „	50 g geschälter Reis, 20 g Kleeheu...	19.18	19.64
13. „	30 g Weizen, 30 g Weizenkleie ...	22.25	21.99
14. „	60 g Weizen, ... ..	13.03	12.87
15. „	18 g Weizen, 36 g Sojabohnenkuchen	18.89	20.12

Das in der 2. Periode verabreichte Gemüse war Grobmehl von getrockneten jungen Brassicablättern. Für die Verdauungskoeffizienten des Grundfutters, nämlich Weizen, wurde der Durchschnittswert von den in den 1., 3. und 14. Perioden erlangten Zahlen benutzt. In der 6. Periode wurde Grobmehl von Fischguano, und in der 7. Grobmehl von kleinen Flussfischen verabreicht. Die Verdauungskoeffizienten des Grundfutters, der Gerste, wurden von den in der 4., 9. und 11. Periode erlangten Zahlen berechnet. Die Menge des in der 8. Periode verabreichten Grundfutters, zu welchem Kartoffelpülpe zugelegt wurde, war gerade ein Drittel der Futtermenge der 7. Periode. Die 12. Periode, bei der Kleeheumehl



und geschälter Reis verabreicht wurde, wurde zum Zwecke des Vergleichs mit den Resultaten der zweiten Fütterungsversuche ausgeführt.

Als diese Versuche vollendet waren, wurden die Hähne operiert. Da aber die Ableitung der Harnleiter von der Kloaka sehr schwierig und bislang noch nicht gelungen ist, so haben wir den Mastdarm von der Kloaka abgetrennt, und einen anus praeternaturalis geschaffen. Letzterer wird zwar häufig beim Menschen sowie auch beim Hunde angelegt, ist aber beim Geflügel noch sehr wenig versucht worden, abgesehen nämlich von *T. H. Milroy* (10), der mit Gänsen, Truthühnern, Enten, von *S. Paraschtschuk*, *Fr. Lehmann*, *Vötz* und *G. Yakuwa*, die mit Hühnern operierten.

Das Operationsverfahren wurde vorher an 5 Hähnen geübt, bevor unser Versuchshahn Nr. 22 erst im April 1912 operiert wurde. Diese Operation ist mit gürtiger Unterstützung von Herrn Tierarzt *S. Uchida* ausgeführt worden, dem ich auch an dieser Stelle meinen verbindlichsten Dank sage. Nach der Eröffnung des Bauchfells wurde eine Schlinge des Rektums durch die Wunde aus der Tiefe hervorgeholt, zwischen zwei Ligaturen durch einen Querschnitt durchgetrennt, also kurz vor der Kloakenöffnung, oberhalb der Einmündung der Harnleiter. Der zur Kloaka führende Stumpf wurde blind geschlossen, und in die Bauchhöhle versenkt, während der Rand des anderen vorgezogenen Darmstückes durch einige Nähte an die Wundränder fixiert wurde, worauf erst die Ligaturen gelöst wurden. Um nun den anus praeternaturalis zu bougieren, wurde ein kurzes Aluminiumröhrchen in die Wunde eingeführt, womit eine durch den Druck der Bauchdecke leicht eintretende starke Verengerung desselben verhindert wurde. Dem operierten Hahn wurden zunächst Wasser, Milch, Aleuronat und Reismehl, danach frische Brassicablätter und andere gewöhnliche Futtermittel verabreicht, und er war schon nach einigen Tagen ausgeheilt.

Nach zehn Tagen wurde die geschilderte Operation an dem zweiten Versuchshahn Nr. 24 ausgeführt. Zwar heilte das Tier auch bald vollständig, aber unerwartet wurde er nach etwa zwei Wochen plötzlich so schwach, dass er nach einigen Tagen zugrunde ging, ohne dass man die eigentliche Ursache finden konnte.

Der Hahn Nr. 22 war immer gesund, sehr lebhaft. Er hat über zwanzig Perioden dauernde Ausnützungsversuche durchgemacht, und die Futterration in allen Perioden vollständig aufgezehrt. Aber die Futtermenge war im Falle deswegen etwas knapp bemessen, um, wenn seine Fresslust je nach der Beschaffenheit der Futtermittel nicht stark genug war, unter allen Umständen einen Futterrest zu vermeiden; eine allgemeine Ursache von Fehlern in den Ausnützungsversuchen wird von der Unregelmässigkeit der Futteraufnahme und von der dementsprechenden Ausscheidung hervorgerufen. Wir haben in der ersten Zeit erfahren, dass die Fresslust des Hahnes dadurch vermindert wurde, dass eine einfache und fade Nahrung dauernd verabreicht wurde, besonders wenn sie verhältnismässig viel Rohfaser enthielt. Da die Bauchöffnung keine eigene Tätigkeit zur Herausbeförderung des Kotes wie die Kloaka besitzt, so tritt leicht eine Verstopfung ein. Insbesondere ist dies der Fall, wenn die Darmmasse viel grobe Rohfaser enthält, wie bei Reisschrot- und Weizenkleieperiode, und wenn der herausgekommene Kotteil am Rande des Bougie etwas getrocknet haften bleibt. Um dieser Störung vorzubeugen, wurde die Bauchöffnung daher jeden Tag dreimal: morgens früh, mittage und abends mittelst einer passenden Pinzette mit dumpfer Spitze abgeräumt. Wenn der Gehalt des Futters an Rohfaser reichlich ist, wurde es noch mehrere male besorgt und die Vorbereitungsperiode auf 6 bis 8 Tage ausgedehnt, womit genauere Durchschnittszahlen für die Ausscheidung erhalten werden sollten.

Um den Harn zu sammeln, wurde in erster Zeit ein Gummibeutel an der Kloaka in der Weise, wie in vorangehenden Versuchen befestigt, indem dabei die Kotteile mittelst Pinzette aufgenommen, teils auf der Glasplatte aufgesammelt wurden. Da aber das Tier einmal, als die Futtermenge ihm ungenügend war, das Aluminiumröhrchen gepickt hat, um den herausgekommenen Kot zu fressen, so wurde der Beutel zum Auffangen des Kotes anstatt des Harnes verwendet, und weiter wurde darin noch ein Becherglas von ca. 150 ccm so eingetan, dass es nicht durch den Schnabel verletzt werden konnte.

Die Futtermittel wurden meistens, abgesehen von einigen Perioden,

von denselben Vorräten verwendet, die im vorangehenden Versuche gebraucht worden waren, und in einer grossen Flasche eingeschlossen gut aufbewahrt. Die Versuche wurden für einige reichlich gelagerte Futtermittel, wie z. B. Gerste und Weizen, mehrmals wiederholt.

In den zwei Vorperioden war es uns lediglich darum zu tun, Analysierproben des Harnes zu erhalten, und der Kot wurde nicht gesammelt. Als die danach folgenden 6 eigentlichen Perioden fertig gestellt waren, trat eine längere Erholungspause ein, um das herabgekommene Tier wieder etwas aufzufüttern, wonach noch 3 Versuchsperioden mit einer nahrhaften Futtermischung von verschiedenen grossen Mengen eingeschoben wurden. Nach der Pause wurden noch 10 Versuchsperioden angestellt, sodass der operierte Hahn im ganzen 21mal die Fütterungsversuche durchgemacht hat. Er war immer noch sehr lebhaft und hatte eine starke Fresslust, wenn aus dem künstlichen After der Kot möglichst gut abgeräumt wurde. Da die Pflege aber viele Arbeit brauchet so habe ich ihn Ende Dezember 1913 getötet.

Die Menge des Futters und die Durchschnittswerte für die Kot- und Harnausscheidung, deren an einzelnen Tagen in jeder Periode erlangte Zahlen in der Tabelle Anhang Nr. 2 zusammengestellt sind, waren folgende :

Zweite Fütterungsversuchsreihe.

	Futter	Kot lufttrocken g	Harn lufttrocken g
1. Vorperiode	Geschälter Reis, Kleeheu (5:2) ...		
2. „	Weizen, Sojabohnenkuchen (1:2) .		
1. Periode	40 g Gerste ... ..	9.30	3.53
2. „	28.55 g Gerste, 21.43 Fischguano.	9.60	5.29
3. „	40 g Weizen ... ..	6.43	2.13
4. „	20 g Weizen, 20 g Weizenkleie...	11.82	6.42
5. „	40 g Gerste ... ..	9.60	2.93
6. „	28.55 g Gerste, 21.43 Fischguano.	10.25	7.07
7. „	90 g Futtermisch ... ..	13.38	8.64
8. „	54 g „ ... ..	8.00	6.57

	Futter	Kot lufttrocken g	Harn lufttrocken g
9. Periode	90 g Futtermisch ... ..	12.15	9.30
10. „	20 g Weizen, 20 g Weizenkleie...	12.48	4.35
11. „	40 g Weizen... ..	6.00	2.65
12. „	20 g Weizen, 20 g getrocknete Kartoffelpülpe ... ..	9.20	1.46
13. „	25 g Weizen, 25 g Weizenkleie ...	14.45	4.08
14. „	50 g Weizen... ..	6.56	3.01
15. „	25 g Weizen, 25 g Reisfuttermehl (Nr. 2) ... ..	13.32	3.51
16. „	40 g ungeschälter Reis ... ..	10.65	2.72
17. „	40 g geschälter Reis, 16 g Kleeheu	10.76	3.41
18. „	10 g Weizen, 20 g Sojabohnen- kuchen ... ..	6.19	5.78
19. „	50 g Weizen ... ..	6.59	3.32

Das in der 7. und 9. Periode verabreichte Futtermisch bestand aus 30 g geschältem Reis, 30 g Weizen, 20 g Aleuronat, 10 g Kleeheu. Die Futtermenge in der 8. Periode war ein Sechzehntel dieses Futtermisches.

## II. CHEMISCHE UNTERSUCHUNGEN ÜBER DIE HARNBESTANDTEILE.

Der Harn des Geflügels, welcher unregelmässig auf dem Kotteile verbreitet wie eine weisse Flocke aussieht, besteht bekanntlich hauptsächlich aus Harnsäure und enthält sehr wenig Harnstoff, während es sich beim Harn des Säugetieres gerade umgekehrt verhält. Aber eine genaue vergleichende Untersuchung über die einzelnen Harnbestandteile der beiden Tierarten ist bislang noch nicht gemacht worden. *O. Mikolowski* hat sich bestrebt zu erfahren, ob die Harnsäure beim Geflügel in der Leber gebildet wird, indem er diese bei Gänsen durch eine Operation exstirpierte und noch den Dickdarm kurz vor der Kloaka ligierte,

wodurch er reinen Harn erhalten hat. Er hat bei diesen Untersuchungen beobachtet, dass die Leber beim Geflügel an der Bildung der Harnsäure den Hauptanteil trägt und dass die bei normalen Gänsen 60–70% des Gesamtstickstoffs betragende Harnsäureausscheidung nach der Operation auf nur 3–6% sank, dagegen 50–60% des Gesamtstickstoffs als Ammoniak ausgeschieden werden. *S. Lang* (11) hat nach ähnlichem Operationsverfahren *Minkowskis* Beobachtung bestätigt, und er hat noch den Harnstickstoff in 3 Teilen unterschieden, nämlich 1. Ammoniak, 2. Harnsäure und Purinbase, 3. Harnstoff u.a. *T. H. Milroy* hat bei Geflügel Ausscheidung der Harnsäure und des Ammoniaks in reinem Harn untersucht, welcher durch das Anlegen von *Anus praeternaturalis* erhalten wurde.

*Harnsäure.*

Der frische Harn, welcher bei unserem Hahn Nr. 22 in jeder Periode gesammelt wurde, sieht weiss aus und besteht aus fester sowie zähflüssiger Masse. Die letztere nahm jedoch, wie wir oftmals beobachteten, bei angem. Stehen oder durch wenige Säure krystallinische Form an. Die getrockneten Analysierproben des Harnes sehen etwas bräunlich-weiss amorph aus und zeigen stets deutlich saure Reaktion.

Obwohl es viele Methoden zur quantitativen Bestimmung der Harnbestandteile gibt, welche bei reinem Harn gebräuchlich sind, können sie aber sehr wenig für die Exkremente (es ist sets Kot und Harn zusammen gemengt!) zur Verwendung kommen. *S. Lang* hat z. B. Harnsäure und Purinbase mit Phosphorwolframsäure bestimmt, aber es ist bei der Beimengung von Kotbestandteilen nicht zuverlässig. *Von Knieriem* hat zur Bestimmung der Harnsäure die Exkremente mit 1.8% Natron extrahiert, die Lösung mit Essigsäure versetzt und schnell filtriert, um Eiweiss zu entfernen, dann das Filtrat mit Salzsäure gesäuert und die Krystalle gesammelt. Aber die Harnsäure kann bei diesem Verfahren nicht nur beim Ansäuern der Alkalilösung mit Essigsäure etwas in Fällung kommend verloren gehen, sondern wegen der starken Anwesenheit von extrahierten Substanzen der Kotbestandteile nicht vollständig auskrystallisiert werden. *E. W. Brown* (12) extrahierte die vorher durch

Alkohol von Farbstoffen befreiten Exkremente der Hühner nach der von *Kionka* vorgeschlagenen und von ihm modifizierten Methode mit Piperidin, dann säuerte er die Lösung mit Salzsäure an, und löste wieder titrimetrisch die Krystalle heiss mit einzehntel normaler Piperidinlösung. Es ist zwar sehr beachtenswert, dass er bei dieser Methode die Proteinsubstanz aus dem Kotteil nicht berührt, aber die Endreaktion der Titration besitzt leider keine grosse Schärfe. Die Fällungsmethode von *Krüger-Schmidt*, sowie von *Ludwig-Salkowski* (13) werden für den Menschenharn sehr häufig gebraucht, jedoch bei unserem Falle deswegen nicht empfohlen, weil die Proteinsubstanzen durch die Kupfer- bzw. Silberlösung gefällt werden können.

Ich habe nach mehreren Versuchen die Exkremente mit Piperazin, einem bekannten Lösungsmittel der Harnsäure, extrahiert und dann die Harnsäure nach Ammoniumuratmethode (13) bestimmt, bei welcher unter andern eine Enteiweissung vorzunehmen ist. Die letztgenannte Methode wurde ursprünglich von *G. Hopkins* vorgeschlagen, ist aber bereits von mehreren Forschern, und hier noch etwas von mir selbst modifiziert worden, wie unten angegeben wird.

Eine fein gemahlene Analysierprobe wird einige Minuten mit ein paar ccm dünner Salzsäure (0,5%) in einem Kolben von 250 ccm erwärmt, um dadurch das Befreien der Harnsäure aus ihren Salzen zu erleichtern, dann mit 120 ccm einprozentiger Piperazinlösung versetzt und in einem kochenden Wasserbade eine halbe Stunde lang extrahiert, wodurch die zuerst am Boden des Kolben befindlichen weissen Harnsäuresalze vollständig gelöst werden. Nach dem Erkalten wird es mit Wasser auf 250 ccm gefüllt und dann filtriert, 100 ccm Filtrat wird mit 30 g Ammoniumchlorid versetzt und eine Viertelstunde im Wasserbade auf etwa 60°C erwärmt. Nach 18-stündigem Stehen wird filtriert, in welcher Zeit alle Harnsäure als Ammoniumurat ausfällt und sich zu Boden setzt. Es war aber ausnahmsweise bei den Exkrementen in der Weizenperiode die Fällung der Harnsäure ziemlich zeitraubend und zuweilen nicht vollständig. Dies scheint auf der relativ grossen Menge (im Vergleich zu anderen Exkrementen) der in Piperazin gelösten

Kotbestandteile begründet zu sein. Dieser Übelstand wird daher nur dadurch beseitigt, dass man 100 ccm Lösung mit ca. 30 ccm Wasser verdünnt und dann mit Ammoniumchlorid bis zu 30% versetzt.

Wenn die Harnsäure mit Ammoniumsulfat nach Folin-Schafferscher Modifikation (13) gefällt wird, so ist der Niederschlag nicht so zäh wie beim Falle von Ammoniumchlorid und kann somit schneller ausgewaschen werden. Trotzdem zog ich deswegen das letztere vor, weil, wenn man eine mit Kot gemengte Probe mit Ammoniumsulfat behandelt, der Niederschlag so fein ist, dass er zum Teil leicht den Filter passieren kann.

Der Niederschlag von Ammoniumchlorid wird mit etwa 50–70 ccm 10 prozentiger Ammoniumsulfatlösung gründlich bis zur Chlorfreiheit ausgewaschen und dann in ein Becherglas mit Wasser quantitativ übergespült. Das Filtrat war manchmal etwas trüb, worin Harnsäure nicht nachgewiesen, jedoch nicht selten bei mehrstündigem Stehen ein weisser Niederschlag entstand. Dies war eine Phosphorsäureverbindung und wurde leicht durch sein Aussehen von Urat unterschieden. In Folin'scher Modifikation wird eine kleine Menge Uranacetat in das Fällungsreagenz eingetan, um vorher die Phosphorsäure aus der zu untersuchenden Lösung zu entfernen, jedoch ist es bei unserem Falle nicht ratsam, weil durch die saure Reaktion ein Teil der Harnsäure bei ihrer reichlichen Anwesenheit leicht mit der Phosphorsäure zusammen in die Fällung kommen kann.

Das im Wasser aufgeschwemmte Ammoniumurat wird mit Salzsäure angesäuert, auf etwa 15 ccm eingedampft und noch einige Tropfen Salzsäure zugesetzt. Nach zwei Tagen wird die auskristallisierte Harnsäure auf einem kleinen Filter gesammelt, mit 50–60 ccm Wasser nachgewaschen. Die Harnsäure samt Filter wird nach Kjeldahl verascht.

Obwohl der Niederschlag von Ammoniumurat durch Auswaschen mit Ammoniumsulfat tunlichst von fremden Substanzen befreit werden soll, wird jedoch bei der Eindampfung der Flüssigkeit eine bräunliche flockige protein- sowie pektinartige Substanz ausgeschieden. Um nun zu erfahren wie gross die Menge dieser Substanz ist, habe ich 5 g reinen Kot mit Piperazin extrahiert, das Filtrat mit Ammoniumchlorid versetzt,

genau in derselben Weise wie zur Harnsäurebestimmung, und dabei gar keine Fällung gefunden. Aber als ich vollständigkeitshalber die Lösung mit Salzsäure ansäuerte und eindampfte, kam eine flockige Substanz in die Fällung, die auf einem Filter gesammelt, mit Wasser nachgewaschen, im ganzen 0.0322 g betrug und ca. 14% N, nämlich im ganzen 0.00454 g N enthielt. Da diese Substanz nicht durch Ammoniumchlorid gefällt wird, sondern nur an dem Niederschlag von Ammoniumurat adhärert und durch saure Reaktion ausgeschieden wird, so kann die Menge nur sehr gering sein, so dass das keine praktische Bedeutung für die Bestimmung der Harnsäure hat. Um jedenfalls den analytischen Fehler tunlichst zu beschränken, wurde die Analyse stets nach eben beschriebenen Verfahren ausgeführt, ausserdem wurde die Analysierprobe vorher in solcher Menge abgewogen, dass die Harnsäure in einer Bestimmung nach der vorläufigen Untersuchung 0.08–0.12 g betragen soll; nämlich in 250 ccm werden 0.4–0.5 g für reinen Harn, 1.0–7.0 g für Exkremente je nach dem Gehalt an Harnsäure aufgelöst.

Um die Genauigkeit unseres analytischen Verfahrens zu prüfen, habe ich einige Vorversuche ausgeführt, indem ich die Methode mehrfach mit reiner Harnsäure, reinem Harn, sowie auch mit Harnsäure veretztem Harn anwandte. Da die wiedergefundenen Werte für die Harnsäure immer in sehr geringer Masse, nur durchschnittlich etwa 1.5% niedriger als die wirklichen waren, was freilich bei derartigen Bestimmungen belanglos blieb, habe ich der Vollständigkeit halber immer durch Multiplizieren der erhaltenen Zahlen mit 101.5% korrigiert. Ich habe dann wiederholt den mit verschiedener Menge der Harnsäure, sowie des Harnes zugesetzten Kot behandelt, und die dadurch wiedergefundenen Prozentsätze waren immer befriedigende, wie aus folgendem Beispiele ersichtlich ist:

0.1 g Harnsäure mit Zusatz

von Kot (g) .....	—	0.48	0.72	0.96	1.20	1.44	1.80	2.16
Wiedergefundener Prozentsatz	100.1	100.5	99.7	98.5	100.4	102.2	101.9	101.5

0.2 g Harn mit Zusatz von Kot (g). ... — 1.0 1.5 2.0

Wiedergefundener Prozentsatz ..... 100.0 99.7 101.1 101.3



*Ammoniak.*

Da der Harnstickstoff der Hühner beinahe ausschliesslich in Form von Ammoniumurat ausgeschieden werden soll, so hat *I. Kalugin* zur gefundenen Menge des Harnsäurestickstoffs bloss 12.5% als Ammoniak addiert, was dem Ammoniakgehalt des Urates entspricht. *Von Knieriem* und *W. Brown* haben Ammoniak in Hühnerexkrement durch die Destillation mit Kalkmilch bezw. Magnesiauster bestimmt. Dies Verfahren ist zwar für reinen Harn, nicht aber für den mit Kot gemengten geeignet, weil ein Teil der Stickstoffsubstanz des Kotes wegen der hohen Temperatur zersetzt und in Ammoniak übergeführt wird. Ich habe daher Exkrementgemenge von Harn und Kot unter Zusatz von Magnesiauster und etwas Kalkmilch auf unter 45°C im Vakuum destilliert. Es war stets in Parallelanalyse sehr gut übereinstimmend, und das im Kot gefundene Ammoniak war ziemlich weniger als bei üblicher Destillation, wie aus folgendem Beispiele ersichtlich ist:

Reiner Kot von Hahn Nr. 22 (zweite Versuchsreihe).

Periode	Futter	Gesamt-N %	Ammoniak-N	
			nach üblichem Verfahren %	nach Vakuum-Destillation %
1.	Gerste ... ..	2.62	0.533	0.054
2.	Gerste, Fischguano ... ..	2.83	0.438	0.048
3.	Weizen ... ..	2.75	0.267	0.012
4.	Weizen, Weizenkleie ... ..	2.49	0.200	0.035
6.	Gerste, Fischguano ... ..	3.35	1.655	0.108

## Exkreme von Hahn Nr. 22 (erste Versuchsreihe).

Periode	Futter	Gesamt- N %	Ammoniak-N	
			nach üblichem Verfahren %	nach Vakuüm- Destillation %
I.	Weizen ... ..	8.97	0.92	0.69
4.	Gerste ... ..	5.20	0.30	0.21
6.	Gerste, Fischguano ... ..	12.45	1.43	0.81
8.	Gerste, getrockn. Fisch, getrockn. Süßkartoffelpülpe ... ..	4.61	0.43	0.33
II.	Gerste ... ..	6.41	0.91	0.52

Der Ammoniak-N im Harn betrug 0.3–3%, durchschnittlich ca. 1.4%, welcher ca. 7% des Harnsäurestickstoffs entsprach und ziemlich weniger als die 12.5% von Kalugin ist. Es ist zwar sehr schwierig, das Ammoniak des Kotes sowie des Harn aus einem gemengten Exkrement gesondert zu bestimmen, aber ich habe gefunden, dass das Ammoniak im Kot, welches jedoch durchaus sehr gering ist, sich ungefähr der Menge des gesamten Kot-N gleich verhält. Seine prozentischer Gehalt im Gesamt-N beträgt 0.3–3.3%, durchschnittlich 2.0%, wie in folgender Tabelle zusammengestellt ist.

	Futter	Kot-N %	Kot- Ammoniak- N %	Am. N im Kot-N %
1. Periode	Gerste ... ..	2.62	0.054	2.00
2. „	Gerste, Fischguano ... ..	2.83	0.048	1.70
3. „	Weizen ... ..	2.75	0.012	0.44
4. „	Weizen, Weizenkleie ... ..	2.49	0.035	1.41
5. „	Gerste ... ..	2.33	0.060	2.50
6. „	Gerste, Fischguano ... ..	3.35	0.108	3.04

	Futter	Kot N %	Kot Ammoniak -N %	Am. N im Kot. N %
7. Periode	Futtergemisch {geschälter Reis, Weizen, Kleeheu, Aleuronat}	4.02	0.132	3.25
8. „	„ „	4.17	0.120	2.76
9. „	„ „	4.04	0.132	3.30
10. „	Weizen, Weizenkleie ... ..	2.45	0.048	1.96
11. „	Weizen ... ..	3.52	0.090	2.38
12. „	Weizen, Süsskartoffelpülpe ... ..	3.30	0.084	2.39
13. „	Weizen, Weizenkleie ... ..	2.22	0.006	0.28
14. „	Weizen ... ..	2.65	0.018	0.72
15. „	Weizen, Reisfuttermehl ... ..	2.18	0.036	1.65
16. „	ungeschälter Reis ... ..	1.82	0.012	0.62
17. „	geschälter Reis, Kleeheu ... ..	2.72	0.090	3.30
18. „	Weizen, Sojabohnenkuchen... ..	4.05	0.120	2.96
19. „	Weizen ... ..	3.36	0.074	2.20

im Durchschnitt 2.04

Schwankung 0.3-3.3

Man kann daher die Menge des Ammoniaks im Kot ohne grösseren Fehler von dem Gesamtstickstoff mittelst der Verwendung der Durchschnittszahl berechnen. Der Gehalt des reinen Harnes in 21 Perioden an Harnsäure und Ammoniak wurde nach dem eben geschilderten Verfahren bestimmt. Wie aus der folgenden Tabelle ersichtlich ist, beträgt der Harnsäure-N durchschnittlich 82% des Gesamt-N, der Ammoniak-N 5.6%, und so bleibt noch ca. 12.4% N unbestimmt übrig, welcher ca. 14.6% der Summe der beiden bestimmten entspricht.

	Futter	Gesamt- N %	Harns. -N %	Am- moniak- -N %	Summe d. beiden N %	Übriger N %	Summe d. beiden N 100: übriger N
Vorperiode	Reis, Kleeheu ... ..	22.25	18.27	0.82	19.09	3.16	16.5
„	Weizen, Sojabohnen- kuchen ... ..	25.48	21.81	1.21	23.02	2.46	10.7
1. Periode	Gerste ... ..	28.16	22.89	0.86	23.75	4.41	18.6
2. „	Gerste, Fischguano ...	27.35	22.40	1.12	23.52	3.83	16.3
3. „	Weizen ... ..	24.48	18.70	1.98	20.68	3.80	18.4
4. „	Weizen, Weizenkleie...	24.66	18.81	2.96	21.77	2.89	13.3
5. „	Gerste ... ..	24.32	18.75	2.04	20.79	3.53	17.0
6. „	Gerste, Fischguano ...	26.76	21.64	2.04	23.68	3.08	13.0
7. „	Futtergemisch ... ..	28.93	25.00	1.57	26.57	2.36	8.9
8. „	„ ... ..	28.08	24.75	1.00	25.75	2.33	9.0
9. „	„ ... ..	29.26	25.54	1.29	26.83	2.43	9.1
10. „	Weizen, Weizenkleie...	26.05	21.58	1.76	23.34	2.71	11.6
11. „	Weizen ... ..	24.65	19.61	1.22	20.83	3.82	18.3
12. „	Weizen, Süßkartoffel- pülpe ... ..	25.89	21.12	1.80	22.92	2.97	13.0
13. „	Weizen, Weizenkleie ..	23.33	18.42	1.42	19.84	3.49	17.6
14. „	Weizen, Reisfutter- mehl... ..	26.66	20.85	1.64	22.89	4.17	18.5
15. „	Weizen ... ..	20.50	15.60	1.49	17.09	3.41	20.0
16. „	Ungeschälter Reis ...	25.23	19.70	1.58	21.28	3.95	18.6
17. „	Geschälter Reis, Kleeheu ... ..	21.06	18.20	0.28	18.48	2.58	14.0
18. „	Weizen, Sojabohnen- kuchen ... ..	27.63	23.80	0.96	24.76	2.87	11.6
19. „	Weizen ... ..	26.43	22.52	1.08	23.60	2.83	12.0
	Im Durchschnitt:	<b>25.57</b>	<b>20.95</b>	<b>1.43</b>		<b>3.19</b>	<b>14.6</b>
		100.0	: 82.0	: 5.6		: 12.4	Schwankung ± 5.5

Es ist nun sehr notwendig, solch eine Methode auszusuchen, wodurch die unbestimmt gebliebenen Stickstoffbestandteile festgestellt werden können.

*S. Lang* hat den Stickstoff des Gänseharnes in der Weise in 3 Teile geteilt, dass er erst das Ammoniak aus reinem Harn durch Magnesia verjagte, dann Harnsäure und Purinkörper mit Phosphor-

wolframsäure fällt, schliesslich den Stickstoff im Filtrat als Harnstoff und Monamidosäure angab. Er hat dabei die Durchschnittswerte für Ammoniak 21–28% gefunden, für Harnsäure und Purinbase 53–66% und für Harnstoff und Monamidosäure 12–18%. Da die letztere unserer unbestimmt gebliebenen Stickstoffmenge beinahe gleich kommt, so habe ich das Langsche Verfahren für unseren Harn und Kot angewandt. Es diente jedoch deswegen unserem Zweck nicht, weil ich immer bei der Behandlung des Kotextraktes mit Phosphorwolframsäure eine nicht unbedeutende Menge des Stickstoffes im Filtrat gefunden habe, die manchmal etwa ein Viertel, sogar ein Drittel des vom Harn erhaltenen Wertes betrug, ausserdem noch der Kot in immer viel grösserer Menge ausgeschieden wird, oft etwa 4 mal so viel als Harn.

Ich habe dann zwar Aminosäures-N in phosphorwolframsaurem Filtrat durch verschiedene Methoden bestimmt, aber das entsprechende vom Kote war immer noch so gross, dass man die Resultate zum Rechnen nicht anwenden kann. Obwohl Harnstoff selbstverständlich allein im Harn ausgeschieden und von dem Filtrat unter Zusatz von Kalk und Phosphorsäure bestimmt werden kann, ist dasselbe aber nicht nur ein kleiner Teil des unbestimmt gebliebenen N, sondern die Analyse ist verhältnismässig umständlich.

Ausserdem können wir nicht ausser acht lassen, dass da noch ein Teil des Harn-N nicht in Piperazin löslich bleibt, wie aus folgenden Zahlen ersichtlich ist, deren Durchschnittswert 0.73% des Harnstickstoffs, nämlich ca. 23% des übrig gebliebenen N beträgt.

	in Piperazin unlöslicher N %	desgl. in Prozenten des übrig gebliebenen N		in Piperazin unlöslicher N %	desgl. in Prozenten des übrig gebliebenen N
Vorperiode	0.81	25.6	4. Periode	0.98	34.6
„	1.01	41.0	5. „	1.21	34.3
I. Periode	0.55	12.5	6. „	1.02	33.2
2. „	0.45	11.7	7. „	0.34	14.4
3. „	0.82	21.6	8. „	0.88	37.8

	in Piperazin unlöslicher N %	desgl. in Prozenten des übrig gebliebenen N		in Piperazin unlöslicher N %	desgl. in Prozenten des übrig gebliebenen N
9. Periode	0.76	31.2	15. Periode	0.52	15.2
10. „	0.52	19.2	16. „	0.75	19.0
11. „	0.42	11.0	17. „	0.63	24.4
12. „	0.41	13.8	18. „	0.67	23.3
13. „	0.72	20.6	19. „	0.75	29.9
14. „	1.21	29.0			
			Im Durchschnitt <b>0.73</b>		<b>23.1</b>

Trotzdem wir uns um die Auflösung des übrig gebliebenen N bemüht haben, ist es uns leider nicht gelungen. Wir wollen un daher damit begnügen, dass wir die Menge des übrig gebliebenen N mit annähernder Genauigkeit durch die Anwendung der Durchschnittszahlen berechnen, die zwar keine bedeutenden Schwankungen zeigten, bis wir eine genaue und bequeme analytische Methode vorlegen können. Wenn man nun den gefundenen Wert für den Gesamt-N mit dem berechneten vergleicht, welcher durch Multiplizieren der Summe von Harnsäure und Ammoniak mit 114.6% (100% + Durchschnittszahl 14.6%) ermittelt wird, so ergeben sich folgende Resultate:

	Futter	Gesamter N %	Summe d. bestim. N %	berechneter N %	Gesamter N 100 : berechnetem N
Vorperiode	Reis, Kleeheu... ..	22.25	19.09	21.88	98.4
„	Weizen, Sojabohnenkuchen ...	25.48	23.02	26.38	103.5
1. Periode	Gerste ... ..	28.16	23.75	27.22	96.7
2. „	Gerste, Fischguano ... ..	27.35	23.52	26.95	98.5
3. „	Weizen ... ..	24.48	20.68	23.70	96.8
4. „	Weizen, Weizenkleie ... ..	24.60	21.77	24.95	101.4

	Futter	Gesamter N %	Summe d. bestim. N %	Berechneter N %	Gesamter N 100: berechnetem N
5.	„ Gerste ... ..	24.32	20.79	23.83	98.0
6.	„ Gerste, Fischguano ... ..	26.76	23.68	27.14	101.5
7.	„ Futtermisch ... ..	28.93	26.57	30.45	105.3
8.	„ „ ... ..	28.08	25.75	29.51	105.1
9.	„ „ ... ..	29.26	26.83	30.75	105.1
10.	„ Weizen, Weizenkleie ... ..	26.05	23.34	26.75	102.7
11.	„ Weizen ... ..	24.65	20.83	23.83	96.9
12.	„ Weizen, Süsskartoffelpülpe ... ..	25.89	22.92	26.27	101.5
13.	„ Weizen, Weizenkleie ... ..	23.33	19.84	27.74	97.5
14.	„ Weizen ... ..	26.66	22.49	25.77	96.7
15.	„ Weizen, Reisfuttermehl ... ..	20.50	17.09	19.59	95.6
16.	„ Ungeschälter Reis... ..	25.23	21.28	24.39	96.7
17.	„ Geschälter Reis, Kleeheu ... ..	21.06	18.48	21.13	100.4
18.	„ Weizen, Sojabohnenkuchen ... ..	27.63	24.76	28.37	102.7
19.	„ Weizen ... ..	26.19	23.60	27.05	103.3

Schwankung 95.6 bis 105.3  
± 5.0 %

Obwohl die Schwankungen sich zwischen 96–105% bewegen, die höchstens ± 5% betragen, nämlich nicht zu klein sind, liegen sie jedoch in bei derartigen Untersuchungen unvermeidlicher Fehlergrenze und das hat keine grosse Bedeutung für die Berechnung der Verdaulichkeit.

*Fett.*

Die in Äther löslichen Substanzen des Harnes, die von der Beschaffenheit des Futters abhängig sein können, betragen 0.8–2.7%, nämlich auf organische Substanz umgerechnet 1.0–3%, durchschnittlich ca. 1.8%, wie in der folgenden Tabelle zusammengestellt:

	Org. Subst. %	Fett %	Fett in org. Subst. %		Org. Subst. %	Fett %	Fett in org. Subst. %
Vorperiode	78.75	1.40	1.78	11. Periode	82.30	0.98	1.12
„	81.40	1.82	2.24	12. „	88.67	2.48	2.80
1. Periode	88.40	2.70	3.06	13. „	81.69	1.25	1.61
2. „	86.75	0.95	1.09	14. „	80.14	0.80	1.00
3. „	84.95	0.83	0.98	15. „	67.72	1.63	2.41
4. „	85.00	1.24	1.46	16. „	81.48	1.76	2.16
5. „	82.00	1.45	1.77	17. „	69.07	1.63	2.36
6. „	85.45	1.36	1.59	18. „	84.40	0.82	0.97
7. „	90.15	2.40	2.66	19. „	81.91	1.17	1.43
8. „	89.60	1.47	1.64				
9. „	90.65	1.92	2.12				
10. „	83.90	0.96	1.14				
						Im Durchschnitt	1.80
						Schwankung	1.0-3.0

Da der Fettgehalt des Harns nur sehr kleine Abweichungen zeigt und durchaus gering ist, so kann man denselben ohne grosse Fehler durch die Anwendung des Durchschnittswertes (1.8%) feststellen.

*Organische Substanz.* Die organischen Substanzen des Kotes wurden bislang von *Kalugin*, *Knieriem* und *Brown* unter der Annahme berechnet, dass die des Harns ausschliesslich aus Ammoniumurat bestehe. Aber ich habe gefunden, dass stets ausser Harnsäure und Ammoniak noch etwa 10-20% andere organische Substanz enthalten ist, welche bei der Beimengung des Kotes kaum oder nur mit grosser Schwierigkeit bestimmt werden kann. Ich habe daher versucht, die organische Substanz im Harn einfach aus dem Harn-N zu berechnen. Diese Substanzen entsprechen 3.1-3.5 mal der Harnstickstoffmenge, durchschnittlich 3.26 mal.

Vergleicht man nun die gefundenen organischen Substanzen (als 100 gesetzt) mit dem mit der Mittelzahl 3,26 berechneten Werte, so ergeben sich folgende Werte, wobei der Fehler höchstens  $\pm 10\%$  beträgt.



	Organische Substanz %	Org. Substanz Gesamter N	Berechnete org. Sub. %	Org. Substanz 100: berechn. Org. Sub.
Vorperiode	78.75	3.54	71.32	90.6
„	81.40	3.19	86.00	105.5
1. Periode	88.40	3.14	88.74	100.4
2. „	86.75	3.17	87.86	101.3
3. „	84.95	3.47	77.26	91.0
4. „	85.00	3.46	81.34	95.7
5. „	82.00	3.37	77.69	94.7
6. „	85.45	3.19	88.48	103.5
7. „	90.15	3.12	99.27	110.1
8. „	89.65	3.19	96.20	107.3
9. „	90.65	3.10	100.25	110.6
10. „	83.90	3.22	87.21	104.0
11. „	82.30	3.34	77.82	94.6
12. „	88.67	3.43	85.64	96.6
13. „	81.69	3.50	74.13	90.8
14. „	80.14	3.01	84.01	104.8
15. „	67.72	3.30	63.86	94.3
16. „	81.48	3.23	79.51	97.6
17. „	69.07	3.28	69.05	100.0
18. „	84.40	3.05	92.49	109.6
19. „	81.91	3.13	88.18	107.5

Im Durchschnitt **3.26** Schwankung 90.6 bis 110.6  
± 10 %

Um nun für die oben erwähnten Verfahren einen besseren Überblick gewinnen zu können, möchte ich dieselben hier kurz in folgenden Formeln zusammenfassen:

Exk. N	bedeutet	Exkrementstickstoff	in Prozent
H. N	„	Harnstickstoff	in Prozent des Exkrementes
K. N	„	Kotstickstoff	„ „ „ „
Hs. N	„	Harnsäurestickstoff	„ „ „ „
H. Am-N	„	Ammoniak-N im Harn	„ „ „ „
Exk. Am-N	„	„	in Prozent des Exkrementes
K. Am-N	„	„	in Kot in Prozent des Exkrementes
H. Org	„	Organische Substanz im Harn	„ „ „ „
H. Fett	„	Fett	„ „ „ „

$$K.N = \text{Exk.} + N - H.N$$

$$K.N = \text{Exk.} N - (\text{Hs.} N + \text{H. Am.} N) \text{ 114.6\%}$$

$$H. \text{ Am.} N = \text{Exk. Am.} N - K. \text{ Am.} N$$

$$H. \text{ Am.} N = \text{Exk. Am.} N - K.N \text{ 2\%}$$

$$K.N = \text{Exk.} N - (\text{Hs.} N + \text{Exk. Am.} N - K.N \text{ 2\%}) \text{ 114.6\%}$$

$$K.N = \text{Exk.} N - (\text{Hs.} N + \text{Exk. Am.} N) \text{ 114.6\% } \cdot 102.3\% \quad \dots (1)$$

$$H.N = \text{Exk.} N - K.N \quad \dots \dots \dots (2)$$

$$H. \text{ Org} = H.N \times 3.26 \quad \dots \dots \dots (3)$$

$$H. \text{ Fett} = H. \text{ Org} \times 1.8\% \dots \dots \dots (4)$$

Wenn auch nicht geleugnet werden kann, dass unser Verfahren mehr oder weniger mit Fehlerquellen behaftet ist, glauben wir jedoch, dass dadurch die Verdauungskoeffizienten des Futters für normale Hühner mit genügender Genauigkeit ermittelt werden können, welche ohne weiteres viel besser sein dürften, als die bislang nur unter Berücksichtigung der Harnsäure und des Ammoniaks erhaltenen.

#### *Aschenbestandteile des Harns.*

Der Aschengehalt des Harns in jeder Periode wird in folgender Tabelle zusammengestellt:

	Futter	Asche d. Harnes %		Futter	Asche d. Harnes %
1. Periode	Gerste... ..	8.00	12. Periode	Weizen, getrocknete Süßkartoffelpülpe ...	7.98
2. „	Gerste, Fischguano ...	8.45	13. „	Weizen, Weizenkleie	13.91
3. „	Weizen ... ..	10.25	14. „	Weizen ... ..	9.41
4. „	Weizen, Weizenkleie..	10.45	15. „	Weizen, Reisfutter- mehl ... ..	22.28
5. „	Gerste... ..	11.15	16. „	Ungeschälter Reis ...	9.85
6. „	Gerste, Fischguano ...	10.50	17. „	Geschälter Reis, Kleeheu ... ..	22.40
7. „	Futtermisch ... ..	6.50	18. „	Weizen, Sojabohnen- kuchen ... ..	11.00
8. „	„ ... ..	6.90	19. „	Weizen ... ..	9.82
9. „	„ ... ..	6.70			
10. „	Weizen, Weizenkleie..	12.20			
11. „	Weizen ... ..	13.70			

Die Menge der Asche wechselt je nach der Beschaffenheit der Futtermittel sehr stark. Man kann daher die Verdaulichkeit der Asche nicht durch den Mittelwert ausrechnen, und es ist deswegen unmöglich, die Trockensubstanz im Harn festzustellen.

Was die Menge der verdauten Aschenbestandteile anbetrifft, so kann dieselbe selbst bei den Säugetieren nicht genau festgestellt werden, weil bekanntlich je nach der Reaktion der Asche des Gesamtfutters einzelne anorganische Stoffe, wie Phosphorsäure, Kalk und Magnesia, bald im Kote, bald im Harn austreten. Hat die Gesamtasche des Futters eine saure Reaktion, so ist auch der Harn sauer und enthält viel Phosphorsäure neben ziemlichen Mengen Kalk und Magnesia; umgekehrt gehen von den genannten Stoffen bei basischer Beschaffenheit der Futterasche nur sehr geringe Beträge in den Harn, die Hauptmasse vielmehr in den Kot über.

Da nun bis jetzt überhaupt noch keine Analyse über die anorganischen Bestandteile des Vogelharns vorliegen, so habe ich dieselben in einigen Harnproben bestimmt, welche den dem Mittel- oder Grenzwerte nahe liegenden Aschengehalt zeigten. Die Asche von 5 bis 10 g Harnprobe wurde zur Bestimmung einzelner Bestandteile benutzt. Die

prozentische Zusammensetzung der Harnasche ist in folgender Tabelle angegeben:

Periode	2. Periode	8. Periode	11. Periode	15. Periode	17. Periode	18. Periode
Futter	Gerste Fischguano	Aleurnat geschälter Reis Weizen Kleeheu	Weizen	Weizen Reisfütter- mehl	Geschälter Reis Kleeheu	Weizen Sojabohnen- kuchen
Trockensubstanz	% 94.39	95.92	95.96	93.83	90.72	95.78
Gesamt-Asche	% 8.45	6.90	13.70	22.28	22.40	11.00
K <sub>2</sub> O	% 14.33	27.03	10.85	22.34	40.96	35.13
Na <sub>2</sub> O	% 28.95	15.21	11.83	8.38	11.27	13.73
CaO	% 6.37	1.62	21.79	5.89	6.20	7.94
MgO	% 7.09	10.00	6.56	3.82	10.32	5.56
Fe <sub>2</sub> O <sub>3</sub>	% Spur	Spur	Spur	Spur	wenig	—
P <sub>2</sub> O <sub>5</sub>	% 34.83	32.81	40.40	57.51	14.97	28.83
SO <sub>3</sub>	% 7.80	15.76	10.14	1.36	9.57	9.43
SiO <sub>2</sub>	% 0.94	0.19	0.09	1.06	0.13	0.20
Cl	% —	wenig	—	—	3.51	—

Wenn man nun die obigen Zahlen aus dem Huhn mit solchen von Säugetieren vergleicht, so ergeben sich: (14)

Tierart	Pferd	Rind	Ziege	Schwein	
Futter	Heu Hafer Stroh	Haferstroh Kleeheu Raps	Grünklee Rüben- blätter	Erbse Kartoffeln saure Milch	Gerste Kartoffeln Milch
Gesamt-Asche	% 2.21	3.60	—	1.20	1.17
K <sub>2</sub> O	% 36.85	} 65.50	34.91	59.59	58.66
Na <sub>2</sub> O	% 3.71		22.48	0.36	0.29
CaO	% 21.92	0.24	0.77	0.36	0.76
MgO	% 4.44	1.47	3.28	1.72	1.64
P <sub>2</sub> O <sub>5</sub>	% Spuren	—	Spur	11.43	11.84
SO <sub>3</sub>	% 17.16	5.32	16.89	—	—
Cl	% 15.36	15.92	13.35	5.90	7.99
SiO <sub>2</sub>	% 0.32	0.49	0.59	9.31	10.05
CO <sub>2</sub>	% —	17.49	10.40	10.98	7.50

Aus diesem Vergleich erkennt man, dass die Harnasche der Hühner an Phosphorsäure immer bedeutend mehr, aber an Kali und Natron etwas weniger enthält als die bei Säugetieren, dies kann sicherlich der sauren Reaktion der Futterasche und des Harns zugeschrieben werden. Kalk und Magnesia sind bei Hühnern ziemlich mehr als bei Säugetieren—vom Pferde abgesehen—enthalten. Entgegen dem grossen Gehalt des Harns an Chlor bei Säugetieren ist dasselbe bei Hühnern deswegen sehr minimal, weil gewöhnlich den Hühnern nicht so viel Kochsalz verabreicht wird.

### 3. *Wärmewert des Harns*

Die kalorimetrische Bestimmung des Geflügelharns ist bislang noch sehr wenig ausgeführt worden, trotzdem dieselbe zur Forschung der Ernährung ebenso wichtig wie beim Säugetiere sein muss. Ich habe daher den Wärmewert des Harns mittelst *Langbein-Hugelshofs* Bombe bestimmt. *O. Kellner* hat bei der Untersuchung des Harns von Säugetieren ein leicht saugbares Papierblöckchen als Hilfsmittel zur Verbrennung benutzt. Aber unsere Harnproben brannten stets sehr leicht aus, ohne dabei derartiges Material zu brauchen. Die Kalorien pro Gramm Trockensubstanz des Harns, sowie auch die auf organische Substanzen umgerechneten sind in folgender Tabelle zusammengestellt:

	Futter	Kalorien pro Gramm Trockensubstanz	Kalorien pro Gramm organische Substanz		Futter	Kalorien pro Gramm Trockensubstanz	Kalorien pro Gramm organische Substanz
Vorperiode	Geschälter Reis, Kleelien	2.243	3.021	5. Periode	Gerste ... ..	2.091	2.982
„	Weizen, Sojabohnenkuchen	2.228	2.868	6. „	Gerste, Fischguano ... ..	2.260	2.880
1. Periode	Gerste ... ..	2.436	2.859	7. „	Futtergemisch..	2.521	2.893
2. „	Gerste, Fischguano ... ..	2.355	2.852	8. „	„	2.527	2.920
3. „	Weizen ... ..	2.327	2.877	9. „	„	2.561	2.902
4. „	Weizen, Weizenkleie...	2.311	2.849	10. „	Weizen, Weizenkleie ...	2.278	2.826
				11. „	Weizen ... ..	2.258	2.858

	Futter	Kalorien pro Gramm Trockensub- stanz	Kalorien pro Gramm organische Substanz		Futter	Kalorien pro Gramm Trockensub- stanz	Kalorien pro Gramm organische Substanz
12. Periode	Weizen, getrock. Süßkartoffel- pülpe ... ..	2.580	3.011	17. Periode	Geschälter Reis, Kleeheu	1.857	2.939
13. „	Weizen, Weizenkleie ...	2.258	2.891	18. „	Weizen, Sojabohnen- kuchen ...	2.267	2.815
14. „	Weizen ... ..	2.070	2.885	19. „	Weizen ... ..	2.129	2.833
15. „	Weizen, Reisfuttermehl	1.806	2.964		Im Durchschnitt	2.267	<b>2.895</b>
16. „	Ungeschälter Reis ... ..	2.200	2.957		Schwankung	1.81 bis 2.58	2.82 bis 3.02

Wie es aus obigen Zahlen deutlich ist, schwankt der Kalorienwert pro Gramm Trockensubstanz sehr stark, ist jedoch dem auf organische Substanz umgerechneten immer annähernd gleich. Der letztere zeigt höchstens einige Prozent Abweichungen von der Durchschnittszahl 2.90 Kal., welcher dem Kalorienwert der Harnsäure (2,75 Kal.), des hauptsächlichsten Bestandteils des Harns, sich nähert. Man kann daher die Kalorien des Harns in jedem Exkrement ohne grosse Fehler einfach durch diese Durchschnittszahl 2.90 berechnen, wenn der Gehalt des Harns an organischer Substanz gefunden werden soll.

#### 4. Verdaulichkeit der Futtermittel durch den operierten Hahn.

Die Futtermittel waren meistens aus denselben Vorräten genommen, welche in vorangegangenen Versuchen für die nicht operierten Hähne besorgt worden sind.

Mit einigen reichlich gelagerten Futtermitteln, wie z.B. Weizen und Gerste, wurde der Versuch oftmals wiederholt, um zu kontrollieren, ob die Fütterungsversuche hindurch glatt gingen.

Die Verdauungskoeffizienten derselben Futtermittel stimmten bei der Wiederholung in verschiedenen Perioden miteinander befriedigend überein,

wie aus den unten dargelegten Tabellen ersichtlich ist.

Die Futtermittel und der Kot in jeder Periode—von der 7., 8. u. 9. Periode abgesehen, welche später besprochen werden—hatten folgende Zusammensetzung, die Futterrations und Kotmenge wurden schon in vorangehender Tabelle (s. Seite 9) angegeben :

Die zweite Versuchsreihe

Futter

Futter	In folgenden Perioden verabreichte	Trock. Sub. %	Org. Sub. %	Rohprotein %	N- freie Extr. St. %	Rohfett %	Rohfaser %	Rohasche %
Gerste ... ..	1, 2, 5, 6, 3, 4, 10, 11, 12, 13, 14, 15	87.67	84.79	13.93	64.16	1.80	4.90	2.88
Weizen ... ..	18, 19	86.58	84.66	14.03	66.47	1.93	2.23	1.92
Fischguano ...	2, 6	90.11	77.81	61.93	2.57	13.31	—	12.30
Weizenkleie ...	4, 10, 13	87.60	82.19	14.87	54.25	4.06	9.01	5.41
Kartoffelpülpe .	12	86.63	81.31	2.44	70.87	1.81	6.19	5.32
Reisfuttermehl Nr. 2 ... ..	15	88.95	77.52	14.13	35.96	19.31	8.12	11.43
Ungeschälter Reis ... ..	16	87.74	80.57	10.48	60.77	1.17	8.15	7.17
Geschälter Reis	17	88.35	86.63	10.45	73.52	1.93	0.73	1.72
Kleemehl ...	17	89.72	76.80	26.92	36.29	2.11	11.48	12.92
Sojabohnen- Kuchen ...	18	89.21	83.00	42.68	28.76	7.23	4.33	6.21

## Kot.

	Trocken- Sub. %	Org. Sub. %	Rohprotein %	N-freie Extrakt- stoffe %	Rohfett %	Rohfaser %	Rohasche %
1. Periode	89.40	80.75	16.38	39.24	4.92	20.21	8.65
2. „	90.55	65.95	17.67	30.46	3.68	14.14	24.60
3. „	87.90	78.25	17.19	39.21	7.20	14.65	9.65
4. „	87.80	77.95	15.13	40.02	5.35	17.45	9.85
5. „	90.15	81.15	14.56	41.33	5.01	20.25	9.00
6. „	91.65	71.15	20.94	33.02	3.47	13.72	20.50
10. „	90.75	81.85	15.31	44.18	5.33	17.03	8.90
11. „	92.45	83.70	22.00	40.44	7.85	13.41	8.75
12. „	90.50	85.05	20.63	41.99	6.05	16.38	5.45
13. „	91.28	83.68	13.88	44.54	5.81	19.45	7.60
14. „	89.80	81.86	16.56	41.65	8.50	15.15	7.94
15. „	89.82	74.26	13.63	35.34	6.24	19.05	15.56
16. „	91.98	69.64	10.38	28.21	1.85	29.20	22.34
17. „	91.12	74.70	17.00	31.20	7.86	18.64	16.42
18. „	89.10	76.76	25.31	28.46	4.27	18.72	12.52
19. „	91.88	83.64	21.00	39.46	7.08	16.10	8.24

Bringt man nun die Ausgaben im Kot von den Einnahmen im Futter in Abzug und berechnet noch nötigenfalls den Teil der verdau-lichen Nährstoffe, welcher aus dem Grundfutter stammt, so ergeben sich für die Verdauungskoeffizienten der betreffenden Futtermittel folgende Werte:



	Organische Substanz g	Roh- protein g	N-freie Extrakt- stoffe g	Rohfett g	Rohfaser g
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Periode I. Gerste

40 g Gerste ... ..	33.92	5.57	25.66	0.72	1.96
9.30 g Kot ... ..	7.51	1.52	3.65	0.46	1.88
Verdaut im ganzen:	26.41	4.05	22.01	0.26	0.08
Verdauungskoeffizienten:	77.9%	72.7%	86.0%	36.1%	4.0%

Periode V. Gerste

40 g Gerste ... ..	33.92	5.57	25.66	0.72	1.96
9.60 g Kot ... ..	7.79	1.40	3.97	0.48	1.94
Verdaut im ganzen:	26.13	4.17	21.69	0.24	0.02
Verdauungskoeffizienten:	77.0%	74.8%	84.5%	33.3%	1.0%
„ im Durchschnitt:	<b>77.5%</b>	<b>73.8%</b>	<b>85.3%</b>	<b>34.7%</b>	<b>2.5%</b>

Periode III. Weizen

40 g Weizen ... ..	33.86	5.61	26.59	0.77	0.89
6.43 g Kot ... ..	5.03	1.11	2.52	0.46	0.84
Verdaut im ganzen:	28.83	4.50	24.07	0.31	0.05
Verdauungskoeffizienten:	85.2%	80.2%	90.5%	40.3%	5.6%

Periode XI. Weizen

40 g Weizen ... ..	33.86	5.61	26.59	0.77	0.89
6.00 g Kot ... ..	5.02	1.32	2.42	0.47	0.81
Verdaut im ganzen:	28.84	4.29	24.17	0.30	0.08
Verdauungskoeffizienten:	85.2%	76.5%	90.9%	39.0%	9.0%

Periode XIV. Weizen

50 g Weizen ... ..	42.33	7.02	33.24	0.97	1.12
6.65 g Kot ... ..	5.44	1.10	2.77	0.57	1.01
Verdaut im ganzen:	36.89	5.92	30.47	0.40	0.11
Verdauungskoeffizienten:	87.2%	84.3%	91.7%	41.2%	9.8%

	Organische Substanz g	Roh- protein g	N-freie Extrakt- stoffe g	Rohfett g	Rohfaser g
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## Periode XIX. Weizen

50 g Weizen ... ..	42.33	7.02	33.24	0.97	1.12
6.59 g Kot ... ..	5.51	1.38	2.60	0.47	1.06
Verdaut im ganzen :	36.82	5.64	30.64	0.50	0.06
Verdauungskoeffizienten :	87.0%	80.3%	92.2%	51.6%	5.4%
„ im Durchschnitt :	<b>86.2%</b>	<b>80.0%</b>	<b>91.3%</b>	<b>43.0%</b>	<b>4.6%</b>

## Periode II. Fischguano

28.55 g Gerste ... ..	24.21	3.98	18.32	0.51	1.40
21.43 g Fischguano ... ..	16.67	13.26	0.55	2.85	—
Gesamtverzehr :	40.88	17.24	18.87	3.36	1.40
9.60 g Kot ... ..	6.33	1.70	2.92	0.35	1.36
Verdaut im ganzen :	34.55	15.54	15.95	3.01	0.04
„ von Gerste :	18.76	2.94	15.63	0.18	0.04
„ von Fischguano :	15.79	12.60	0.32	2.83	0.00
Verdauungskoeffizienten :	94.7%	95.0%	58.2%	99.3%	—

## Periode VI. Fischguano

Gesamtverzehr wie Periode II.	40.88	17.24	18.87	3.36	1.40
10.25 g Kot ... ..	7.29	2.15	3.38	0.36	1.41
Verdaut im ganzen :	33.59	15.09	15.49	3.00	— 0.01
„ von Gerste :	18.76	2.94	15.63	0.18	0.04
„ „ Fischguano :	14.83	12.15	— 0.14	2.82	— 0.05
Verdauungskoeffizienten :	89.0%	91.9%	—	99.0%	—
„ im Durchschnitt :	<b>91.9%</b>	<b>93.3%</b>		<b>99.2%</b>	

## Periode IV. Weizenkleie

20 g Weizen ... ..	16.93	2.81	13.29	0.39	0.45
20 g Weizenkleie ... ..	16.44	2.97	10.85	0.81	1.81
Gesamtverzehr :	33.37	5.78	24.14	1.20	2.25
11.82 g Kot ... ..	0.21	1.79	4.73	0.63	2.06

	Organische Substanz g	Roh- protein g	N-freie Extrakt- stoffe g	Rohfett g	Rohfaser g
Verdaut im ganzen :	24.16	3.99	19.41	0.57	0.19
„ von Weizen :	14.53	2.24	12.13	0.17	0.02
„ „ Weizenkleie :	9.63	1.75	7.28	0.40	0.17
Verdauungskoeffizienten :	58.7%	63.1%	67.1%	49.4%	9.5%

Periode X. Weizenkleie

25 g Weizen ... ..	21.17	3.51	16.62	0.48	0.56
25 g Weizenkleie ... ..	20.55	3.72	13.56	1.01	2.25
Gesamtverzehr :	41.72	7.23	30.18	1.49	2.81
14.45 g Kot ... ..	12.09	2.00	6.44	0.84	2.81
Verdaut im ganzen :	29.63	5.23	23.74	0.65	0.00
„ von Weizen :	18.25	2.80	15.17	0.21	0.03
„ „ Weizenkleie :	11.38	2.43	8.57	0.44	— 0.03
Verdauungskoeffizienten :	55.4%	65.3%	63.2%	43.6%	—
„ im Durchschnitt :	<b>55.5%</b>	<b>62.4%</b>	<b>63.4%</b>	<b>45.8%</b>	<b>4.9%</b>

Periode XII. Kartoffelpülpe

20 g Weizen ... ..	16.93	2.81	13.29	0.30	0.45
20 g Kartoffelpülpe ... ..	16.26	0.49	14.17	0.36	1.24
Gesamtverzehr :	33.19	3.30	27.47	0.75	1.69
9.20 g Kot ... ..	7.83	1.90	3.86	0.56	1.51
Verdaut im ganzen :	25.36	1.40	23.60	0.19	0.18
„ von Weizen :	14.53	2.24	12.13	0.17	0.02
„ „ Kartoffelpülpe :	10.83	0.84	11.47	0.02	0.16
Verdauungskoeffizienten :	<b>66.8%</b>	-	<b>80.9%</b>	<b>5.6%</b>	<b>12.9%</b>

Periode XV. Reisfüttermehl

25 g Weizen ... ..	21.17	3.51	16.62	0.48	0.56
25 g Reisfüttermehl ... ..	19.38	3.53	8.99	4.83	2.03
Gesamtverzehr :	40.55	7.04	25.61	5.31	2.59
13.32 g Kot ... ..	9.85	1.82	4.71	0.83	2.54

	Organische Substanz g	Roh- protein g	N-freie Extrakt- stoffe g	Rohfett g	Rohfaser g
Verdaut im ganzen :	30.66	5.22	20.90	4.48	0.05
„ von Weizen :	18.25	2.80	15.17	0.21	0.03
„ „ Reisfuttermehl :	12.41	2.42	5.73	4.27	0.02
Verdauungskoeffizienten :	<b>64.0%</b>	<b>71.1%</b>	<b>63.7%</b>	<b>88.4%</b>	—

## Periode XVIII. Sojabohnenkuchen

10 g Weizen ... ..	8.47	1.40	6.65	0.19	0.22
20 g Sojabohnenkuchen ... ..	16.60	8.54	5.75	1.45	0.87
Gesamtverzehr :	25.07	9.94	12.40	1.64	1.09
6.91 g Kot ... ..	4.75	1.57	1.76	0.26	1.16
Verdaut im ganzen :	20.32	8.37	10.64	1.38	— 0.07
„ von Weizen :	7.27	1.12	6.06	0.09	0.01
„ „ Sojabohnenkuchen :	13.05	7.25	4.58	1.29	— 0.08
Verdauungskoeffizienten :	<b>78.6%</b>	<b>84.9%</b>	<b>79.7%</b>	<b>89.0%</b>	

## Periode XVI. Ungeschälter Reis

40 g Ungeschälter Reis... ..	23.23	4.19	24.31	0.47	3.26
10.65 g Kot ... ..	7.42	1.11	3.00	0.20	3.11
Verdaut im ganzen :	15.81	3.08	21.31	0.27	0.15
Verdauungskoeffizienten :	<b>77.0%</b>	<b>73.5%</b>	<b>87.7%</b>	<b>5.75%</b>	<b>4.6%</b>

## Periode XVII. Geschälter Reis u. Kleemehl

40 g Geschälter Reis ... ..	34.65	4.18	29.41	0.77	0.29
16 g Kleemehl ... ..	12.29	4.31	5.81	0.34	1.84
Gesamtverzehr :	46.94	8.49	35.22	1.11	2.13
10.76 g Kot ... ..	8.04	1.83	3.36	0.85	2.01
Verdaut im ganzen :	38.90	6.66	31.86	0.26	0.12
Verdauungskoeffizienten :	<b>82.9%</b>	<b>78.4%</b>	<b>90.5%</b>	<b>23.4%</b>	<b>5.6%</b>

Die Einzelheiten über die Verdauung will ich später zugleich mit den entsprechenden in der vorangegangenen Versuchsreihe mit den unoperierten Hähnen besprechen.

In der 7., 8. u. 9. Periode habe ich dem Hahn eine nahrhafte Futtermischung verschieden grosser Menge verabreicht, um einerseits das herabgekommene Tier etwas aufzufüttern und andererseits zu erkennen, ob die Menge des Futters einen Einfluss auf die Ausnutzung desselben haben kann, weil das Futterquantum in der vorstehenden Versuchsreihe etwas knapper war, als bei der vorangegangenen.

Bei Untersuchungen, welche *O. Kellner* (15) an Wiederkäuern mit einem Gemisch von Rauhfutterstoffen und konzentrierten Futtermitteln ausgeführt hat, stellte sich heraus, dass der Umfang der Verdauung etwas abnahm, wenn die Futtermenge höher bemessen wurde. Der genannte Forscher vermutete, dass beim Verzehr grosser Futtermassen ein etwas rascherer Durchgang des Futterbreis durch den Verdauungskanal stattfindet, obwohl der letztere eine gewisse Dehnbarkeit besitze.

Auch ist es möglich, dass die Darmfläche bei ausschliesslicher Aufnahme von hoch verdaulichen Stoffen nicht ausreicht, um alles Verdaute in die Körpersäfte aufzunehmen. Bei dem Versuche, welche ich (16) an Schweinen einmal mit einer möglichst grossen Futtermenge, abermals nur mit der Hälfte der Menge ausgeführt habe, habe ich zwar erwartet, dass hier Unterschiede in der Verdauung eher zu beobachten sein werden, als bei Rindern und Schafen, weil diese Tiere einen weniger geräumigen Magen und einen kürzeren Darmschlauch besitzen, als die Wiederkäuer. Aber die Resultate sprechen dafür, dass das Futter in beiden Versuchsabschnitten von den Tieren gleich verdaut wurde. Es ist mir nun sehr interessant, Versuche dieser Art wiederum mit Hühnern anzustellen, da ihre Verdauungsorgane viel kleiner und kürzer sind, als die der Schweine.

Ich ging in der 7ten Periode von einer grossen Menge einer Futtermischung aus, welche bestand aus:

30 g	geschältem Reis
30 „	Weizen

20 g Aleuronat  
10 „ Kleeheu

Danächst wurde in der 8. Periode nur ein Sechszehntel der eben angeführten Futtermenge zum Verzehr gebracht. Schliesslich wurde in der 9. Periode wiederum mit der ebenso starken Ration wie bei der 7. Periode wiederholt.

Die Futtermittel hatten folgende Zusammensetzung:

## Futter

	Trocken-Substanz %	Organische Substanz %	Kohprotein %	N-freie Extraktstoffe %	Kohfett %	Kohfaser %	Asche %
Aleuronat ... ..	91.50	90.22	89.69	0.28	0.25	—	1.28
Geschälter Reis ...	88.35	86.63	10.45	73.52	1.93	0.73	1.72
Weizen... ..	86.58	84.66	14.03	66.47	1.93	2.23	1.92
Kleeheu ... ..	89.72	76.80	26.92	36.29	2.11	11.48	12.92

Der Kot wurde täglich in der 7ten mit 13.38 g, in der 8ten mit 8.00 g, in der 9ten Periode mit 12.15 g in der Luftrockensubstanz ausgeschieden. Darin war enthalten in Prozenten:

## Kot

	Trocken-Substanz %	Organische Substanz %	Kohprotein %	N-freie Extraktstoffe %	Kohfett %	Kohfaser %	Asche %
Periode VII ... ..	90.85	78.30	25.63	31.25	6.70	15.22	12.55
„ VIII ... ..	92.20	79.35	26.06	26.06	5.64	15.27	12.85
„ IX ... ..	93.20	80.10	25.25	25.25	6.93	16.45	13.10

Aus dem Futterverzehr und der Kotalausscheidung berechnen sich die Verdauungskoeffizienten der Futtermischung bei den drei Perioden wie folgt:

	Organische Substanz g	Roh- protein g	N-freie Extraktstoffe g	Rohfett g	Rohfaser g
Periode VII.					
20 g Aleuronat ... ..	18.04	17.94	0.06	0.05	—
30 g geschälter Reis ... ..	25.99	3.14	22.06	0.58	0.22
30 g Weizen ... ..	25.40	4.21	19.94	0.58	0.67
10 g Kleeheu... ..	7.68	2.69	3.63	0.21	1.15
Gesamtverzehr ... ..	77.11	27.98	45.69	1.41	2.04
13.38 g Kot ... ..	10.48	3.36	4.18	0.90	2.03
Verdaut im ganzen ... ..	66.63	24.62	41.51	0.52	0.01
Verdauungskoeffizienten ... ..	<b>68.4%</b>	<b>88.0%</b>	<b>90.9%</b>	<b>36.6%</b>	<b>0.5%</b>
Periode VIII.					
60% der Futtermenge von					
Periode VII. ... ..	46.27	16.79	27.41	0.85	1.22
8.00 g Kot ... ..	6.35	2.08	2.59	0.45	1.22
Verdaut im ganzen ... ..	39.92	14.71	24.82	0.40	0.00
Verdauungskoeffizienten ... ..	<b>86.3%</b>	<b>87.6%</b>	<b>90.5%</b>	<b>47.1%</b>	<b>0.0%</b>
Periode IX.					
Gesamtverzehr wie Periode VII. ...	77.11	27.98	45.69	1.42	2.04
12.15 g Kot ... ..	9.73	3.07	3.82	0.84	2.00
Verdaut im ganzen ... ..	67.38	24.91	41.87	0.58	0.04
Verdauungskoeffizienten ... ..	<b>87.5%</b>	<b>89.0%</b>	<b>91.6%</b>	<b>40.9%</b>	<b>1.7%</b>

Es sind also, wie aus der Tabelle hervorgeht, in Prozenten an Futterbestandteilen verdaut worden:

	Organische Substanz %	Rohprotein %	N-freie Extraktstoffe %	Rohfett %	Rohfaser %
Bei der starken Ration... ..	86.9	88.5	91.2	38.7	1.1
„ schwachen Ration ... ..	86.3	87.6	90.5	47.1	0.0
Differenz... ..	0.6	0.9	0.7	— 8.4	1.1

Vorstehende Berechnungen belehren, dass das Futter in drei Versuchsabschnitten von dem Versuchstier gleich verdaut wurde, und die Menge des Futters daher einen Einfluss auf die Ausnützung desselben nicht gehabt hat. Im einzelnen erkennen wir, dass die Ausscheidung von ätherlöslicher Substanz im Kote bei starken Rationen eine etwas grössere war als bei schwachen, woraus sich ein Unterschied der Verdauungskoeffizienten ergab. Es muss aber höchstwahrscheinlich der Beimischung ätherlöslicher Stoffwechselprodukte zum Kote zugeschrieben werden, da ähnliche Beobachtungen schon mehrfach bei Säugetieren gemacht worden sind.

##### 5. Kalorimetrische Untersuchungen des Futters und Kotes

Für den Kalorienwert (Kal) pro Gramm (Lufttrockensubstanz) des Futters und Kotes in der zweiten Versuchsreihe haben wir folgende Zahlen erhalten:

##### Futter

Gerste ... .. 3.908	Weizen ... .. 3.880	Fischguano... .. 4.921
Weizenkleie ... .. 4.016	Kartoffelpülpe ... .. 3.532	Reisfuttermehl Nr. 2. 4.688
Ungeschälter Reis ... 3.710	Geschälter Reis ... .. 3.677	Klecheu ... .. 3.637
Sojabohnenkuchen ... 4.774	Aleuronat ... .. 5.197	



Kot

Periode I ... .. 4.132	Periode VIII ... .. 4.294	Periode XV ... .. 3.952
„ II ... .. 3.412	„ IX ... .. 4.455	„ XVI ... .. 3.621
„ III ... .. 4.033	„ X ... .. 4.203	„ XVII ... .. 4.004
„ IV ... .. 4.101	„ XI ... .. 4.429	„ XVIII ... .. 3.959
„ V ... .. 4.203	„ XII ... .. 4.004	„ XIX ... .. 4.390
„ VI ... .. 3.812	„ XIII ... .. 4.262	
„ VII ... .. 4.297	„ XIV ... .. 4.305	

Der Kalorienwert für die Tagesmenge der verdauten organischen Substanz und derselbe in Prozenten des gesamten Wärmewertes der Futterration sind folgende:

Versuchs- periode	Futterration	Kot- menge g	Einnahme im Futter Kal	Ausgabe im Kote Kal	Wärmewert der verdauten organ. Substanz Kal	desgl. in Prozen- ten des Wärme- wertes von Futter- ration %
Periode I	40 g Gerste ... ..	9.30	156.3	38.4	117.9	75.4
„ II	{ 28.55 g Gerste... .. } { 21.43 g Fischguano... .. }	9.60	217.0	32.8	184.2	84.9
„ III	40 g Weizen ... ..	6.43	155.2	25.9	129.3	83.3
„ IV	{ 20 g Weizen ... .. } { 20 g Weizenkleie ... .. }	11.28	168.5	48.5	120.0	71.3
„ V	40 g Gerste ... ..	9.60	156.2	40.3	116.0	74.2
„ VI	{ 28.55 g Gerste... .. } { 21.43 g Fischguano ... .. }	10.25	217.0	39.1	177.9	82.0
„ VII	Futtergemisch ... ..	13.38	367.0	57.5	309.5	84.3
„ VIII	{ 60% der Futtermenge von } { Periode VII. ... .. }	8.00	220.2	34.4	185.8	84.4
„ IX	Futtermenge wie Periode VII.	12.15	367.0	54.1	312.9	85.3
„ X	{ 20 g Weizen ... .. } { 20 g Weizenkleie ... .. }	12.48	168.5	52.5	116.0	68.8
„ XI	40 g Weizen ... ..	6.00	155.2	26.6	128.6	82.8
„ XII	{ 20 g Weizen ... .. } { 20 g Kartoffelpülpe ... .. }	9.20	148.2	36.8	111.4	75.2
„ XIII	{ 25 g Weizen ... .. } { 25 g Weizenkleie ... .. }	14.45	198.1	61.6	136.5	68.9
„ XIV	50 g Weizen ... ..	6.65	194.0	28.6	165.4	85.2
„ XV	{ 25 g Weizen ... .. } { 25 g Reisfuttermehl ... .. }	13.32	214.2	52.6	161.6	75.4
„ XVI	40 g Ungeschälter Reis ... ..	10.65	148.4	38.5	109.9	74.0
„ XVII	{ 40 g Geschälter Reis ... .. } { 16 g Kleheu ... .. }	10.76	205.3	43.1	162.2	79.0
„ XVIII	{ 10 g Weizen ... .. } { 20 g Sojabohnenkuchen ... .. }	6.19	134.2	24.5	109.7	81.7
„ XIX	50 g Weizen ... ..	6.59	194.0	28.9	165.1	85.1

Eine Beschreibung von Einzelheiten folgt später.

6. *Verdaulichkeit von Futtermitteln durch den normalen Hahn*

Wie schon vorher dargelegt wurde, wurden in der ersten Versuchsreihe 15 Ausnutzungsversuche derjenigen Futtermittel durch zwei normale Hähne ausgeführt, welche meistens (fast alle) wiederum in der zweiten Versuchsreihe dem operierten Hahn verabreicht wurden.

Die Futtration und die Exkrementmenge in dieser Versuchsreihe wurden schon am Anfang dargelegt (s. Seite. 6). Das Futter hatte nun folgende chemische Zusammensetzung:

Die erste Versuchsreihe

Das Futter

Futter	In folgenden Perioden verabreicht	Trocken- Substanz %	Organische Substanz %	Rohprotein %	N-freie Extraktstoffe %	Rohfett %	Rohfaser %	Asche %
Weizen... ..	I. II. III. XIV. XV.	87.75	89.60	14.00	67.99	1.83	2.18	17.6
Gerste ... ..	IV. V. VI. VII. IX. XI. XIII.	86.83	84.08	13.66	63.77	1.85	4.80	2.75
Fischguano ... ..	VI.	89.34	76.57	60.06	2.84	13.67	—	12.77
Kartoffelpülpe ...	VIII.	87.87	82.11	2.60	71.24	1.94	6.33	5.76
Reisfuttermehl Nr. I. ... ..	V.	91.15	54.76	11.00	25.89	11.25	6.62	36.39
Ungeschälter Reis.	X.	88.31	81.64	10.20	67.50	1.20	7.74	6.67
Geschälter Reis ...	XII.	87.95	86.35	9.74	73.68	2.17	0.76	1.70
Weizenkleie... ..	XIII.	87.85	82.75	15.34	53.67	4.79	8.95	5.11
Sojabohnenkuchen.	XV.	87.97	82.07	41.82	27.74	7.70	4.76	5.90
Kleeheu ... ..	XII.	89.01	76.56	26.17	36.79	2.41	11.19	12.45
GetrockneteGemüse	II.	89.47	76.35	18.94	42.22	2.14	8.05	13.12
Getrockneter Fisch	VII.	93.91	74.38	50.01	3.70	14.67	—	19.53

Da die Harnsäure in den Exkrementen unregelmässig in weissen Flocken verbreitet vorhanden ist, so muss man die Analysierproben mit grosser Sorgfalt fein mahlen, so dass die Flocken tunlichst gleichmässig verteilt werden. Die Analyse der Exkremente erstreckte sich zunächst auf folgende Bestandteile: Trockensubstanz, organische Substanz, Fett, Rohfaser und Asche. Die Analysen sind in folgender Tabelle zusammengestellt:

Exkremente, Hahn Nr. 22

				Trocken-Substanz	Organische Substanz	Rohfett	Rohfaser	Asche
				%	%	%	%	%
Periode	I.	...	...	89.29	80.77	5.63	9.20	8.52
„	II.	...	...	90.50	75.92	4.05	12.51	14.58
„	III.	...	...	92.28	84.92	5.44	9.49	7.36
„	IV.	...	...	95.24	84.49	2.84	16.82	10.75
„	V.	...	...	92.10	51.64	2.68	11.14	40.46
„	VI.	...	...	93.75	77.38	2.60	7.50	16.37
„	VII.	...	...	94.47	71.96	2.03	7.20	22.51
„	VIII.	...	...	95.00	78.99	2.94	13.99	16.01
„	IX.	...	...	91.85	82.62	3.33	16.33	9.23
„	X.	...	...	92.43	71.05	1.69	25.64	21.38
„	XI.	...	...	90.57	79.70	3.62	14.10	10.87
„	XII.	...	...	90.10	74.10	4.80	13.85	16.00
„	XIII.	...	...	89.25	79.84	4.41	14.52	9.41
„	XIV.	...	...	89.91	80.90	5.91	10.52	9.01
„	XV.	...	...	93.45	80.09	2.31	11.48	13.36

## Exkreme, Hahn Nr. 24

					Trocken- Substanz	Organische Substanz	Rohfett	Rohfaser	Asche
					%	%	%	%	%
Periode	I.	...	...	...	90.44	81.63	4.76	9.08	8.76
„	II.	...	...	...	90.92	75.51	4.18	12.61	15.41
„	III.	...	...	...	94.77	85.96	5.28	10.13	7.81
„	IV.	...	...	...	95.37	85.62	2.55	17.25	9.75
„	V.	...	...	...	93.84	52.36	2.05	11.56	41.48
„	VI.	...	...	...	91.43	74.62	1.80	6.85	16.81
„	VII.	...	...	...	94.58	71.42	1.58	7.41	23.16
„	VIII.	...	...	...	93.26	74.81	3.02	13.85	18.45
„	IX.	...	...	...	92.46	82.82	2.73	15.87	9.64
„	X.	...	...	...	92.97	71.83	1.40	24.22	21.14
„	XI.	...	...	...	92.37	83.31	2.99	14.33	9.06
„	XII.	...	...	...	89.30	73.20	4.48	13.78	16.10
„	XIII.	...	...	...	91.13	81.28	4.24	14.55	9.85
„	XIV.	...	...	...	90.46	82.05	4.25	10.62	8.41
„	XV.	...	...	...	94.45	81.83	1.83	10.76	12.62

Um nunmehr die Verdaulichkeit der Futtermittel festzustellen, wurde der Stickstoff des Kotes und des Harns in einem Exkreme, sowie auch organische Substanz und Fett des Harns nach den oben erörterten Verfahren (s. Seite 24) untersucht. Es ergab sich folgendes Resultat in Prozenten des Exkremes:

Exkreme, Hahn Nr. 22

	Gesamt-N %	Harnsäure-N %	Ammoniak-N %	Summe d. beiden N %	Kot-N %	Harn-N %	Harn Organ. Substanz %	Harnfett %
Periode I .....	8.97	5.27	0.69	5.96	2.19	6.78	22.10	0.40
„ II .....	6.99	4.19	0.55	4.74	1.60	5.39	17.57	0.32
„ III .....	8.20	4.75	0.50	5.25	2.23	5.97	19.46	0.35
„ IV .....	5.20	2.80	0.21	3.01	1.79	3.41	11.12	0.20
„ V .....	3.36	1.66	0.25	1.91	1.20	2.16	7.04	0.13
„ VI .....	12.45	8.27	0.81	9.08	2.10	9.35	33.74	0.61
„ VII .....	10.79	7.25	0.29	7.54	2.30	8.49	27.68	0.50
„ VIII .....	4.61	2.36	0.33	2.69	1.57	3.04	9.91	0.18
„ IX .....	5.85	3.11	0.52	3.63	1.73	4.12	13.43	0.24
„ X .....	4.72	2.57	0.58	3.15	1.14	3.58	11.67	0.21
„ XI .....	6.41	3.66	0.52	4.18	1.67	7.47	15.45	0.28
„ XII .....	7.30	4.42	0.34	4.76	1.90	5.40	17.60	0.32
„ XIII .....	5.05	2.31	0.53	2.84	1.84	3.21	10.46	0.19
„ XIV .....	8.16	4.75	0.85	5.60	1.79	6.37	20.77	0.37
„ XV .....	12.23	7.31	0.92	8.23	2.86	9.37	30.55	0.55

Exkreme, Hahn Nr. 24

	Gesamt-N %	Harnsäure-N %	Ammoniak-N %	Summe d. beiden N %	Kot-N %	Harn-N %	Harn Organ. Substanz %	Harnfett %
Periode I .....	9.09	5.67	0.93	6.60	1.57	7.52	24.52	0.44
„ II .....	8.40	5.17	0.66	5.83	1.76	6.64	21.65	0.39
„ III .....	8.87	5.12	0.56	5.68	2.41	6.46	21.06	0.38
„ IV .....	5.46	2.95	0.28	3.23	1.80	3.66	11.93	0.22
„ V .....	3.47	1.82	0.27	2.09	1.09	2.38	7.76	0.14
„ VI .....	11.64	7.75	0.90	8.65	1.77	9.87	32.18	0.58
„ VII .....	10.38	7.03	0.62	7.65	1.65	8.73	28.46	0.51
„ VIII .....	4.50	1.90	0.36	2.26	1.95	2.55	8.31	0.15
„ IX .....	6.35	3.75	0.60	4.10	1.69	4.66	15.17	0.27

	Gesamt-N %	Harnsäure-N %	Ammoniak-N %	Summe d. beiden N %	Kot-N %	Harn-N %	Harn-Organ. Substanz %	Harnfett %
Periode X .....	6.40	3.80	0.83	4.63	1.12	5.28	17.21	0.31
„ XI .....	7.04	4.20	0.67	4.87	1.49	5.55	18.09	0.33
„ XII .....	6.92	4.03	0.44	4.47	1.84	5.08	16.56	0.30
„ XIII .....	5.12	2.33	0.61	2.94	1.79	3.33	10.86	0.20
„ XIV .....	8.40	4.57	0.94	5.51	2.15	6.25	20.38	2.37
„ XV .....	11.99	7.52	0.94	8.46	2.34	9.65	31.46	0.57

Aus obigen Zahlen wurden nun die Kotbestandteile in Prozenten des Exkrementes berechnet, indem dabei die Kot-Organ. Substanz von der Differenz der Exkrement- und Harn-Organ. Substanz, sowie auch Kotfett vom Exkrement- und Harnfett beziehungsweise, und Kotprotein durch das Multiplizieren des Kotstickstoffs mit 6.25 ermittelt wurden:

## Kot, Hahn Nr. 22

	Organische Substanz %	Rohprotein %	N-freie Extraktstoffe %	Rohfett %	Rohfaser %
Periode I ... ..	58.67	13.69	30.55	5.23	9.20
„ II ... ..	58.35	10.00	32.11	3.73	12.51
„ III ... ..	65.46	13.94	36.94	5.09	9.49
„ IV ... ..	73.37	11.19	42.72	2.64	16.82
„ V ... ..	44.60	7.50	23.41	2.55	11.14
„ VI ... ..	43.64	13.13	21.02	1.99	7.50
„ VII ... ..	44.28	14.38	21.17	1.53	7.20
„ VIII ... ..	69.08	9.81	42.52	2.76	13.99
„ IX ... ..	69.19	10.81	38.96	3.09	16.33
„ X ... ..	59.38	7.31	24.95	1.48	25.64
„ XI ... ..	64.25	10.44	36.37	3.34	14.10
„ XII ... ..	56.50	11.88	26.29	4.48	13.85
„ XIII ... ..	69.38	11.50	39.14	4.22	14.52
„ XIV ... ..	60.13	11.19	32.88	5.54	10.52
„ XV ... ..	49.54	17.88	18.42	1.76	11.48

Kot, Hahn Nr. 24

	Organische Substanz %	Roh- protein %	N-freie Extrakt- stoffe %	Rohfett %	Rohfaser %
Periode I. ... ..	57.11	9.81	33.90	4.32	9.08
„ II. ... ..	53.86	11.00	26.46	3.79	12.61
„ III. ... ..	64.90	15.06	34.82	4.90	10.12
„ IV. ... ..	73.69	11.25	42.85	2.34	17.25
„ V. ... ..	44.60	6.81	24.32	1.91	11.56
„ VI. ... ..	42.44	11.06	23.31	1.22	6.85
„ VII. ... ..	42.96	10.31	24.17	1.07	7.41
„ VIII. ... ..	66.50	12.19	32.59	2.87	13.85
„ IX. ... ..	67.65	10.57	38.79	2.42	15.87
„ X. ... ..	54.62	7.00	22.31	1.05	24.22
„ XI. ... ..	65.22	9.31	38.92	2.66	14.33
„ XII. ... ..	56.64	11.50	27.18	4.18	13.78
„ XIII. ... ..	70.42	11.19	40.63	4.05	14.55
„ XIV. ... ..	61.67	13.44	33.73	3.88	10.62
„ XV. ... ..	50.37	14.63	23.72	1.26	10.76

Berechnet man nun aus den Einnahmen im Futter und den Ausgaben im Kote die Verdauungskoeffizienten für das Futtermittel, so ergeben sich folgende Werte:

	Organische Substanz g	Roh- protein g	N-freie Extrakt- stoffe g	Rohfett g	Rohfaser g
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## Periode I. Weizen, Hahn Nr. 22

60 g Weizen ... ..	51.60	8.40	40.79	1.10	1.31
14.59 g Exkrement ... ..	8.55	1.99	4.46	0.76	1.34
Verdaut im ganzen :	43.05	6.41	36.33	0.34	— 0.03
Verdauungskoeffizienten :	<b>83.5%</b>	<b>76.2%</b>	<b>89.0%</b>	<b>30.9%</b>	

## Hahn Nr. 24

60 g Weizen ... ..	51.60	8.40	40.79	1.10	1.31
14.01 g Exkrement ... ..	8.00	1.37	4.75	0.60	1.27
Verdaut im ganzen :	43.60	7.03	36.04	0.49	0.04
Verdauungskoeffizienten :	84.4%	83.7%	88.3%	44.5%	3.1%

## Periode III. Weizen, Hahn Nr. 22

60 g Weizen ... ..	51.60	8.40	40.79	1.10	1.31
15.10 g Exkrement ... ..	9.88	2.11	5.57	0.77	1.41
Verdaut im ganzen :	41.72	6.29	35.22	0.33	— 0.12
Verdauungskoeffizienten :	80.9%	74.9%	86.2%	30.0%	

## Hahn Nr. 24

60 g Weizen ... ..	51.60	8.40	40.79	1.10	1.31
14.74 g Exkrement ... ..	9.57	2.22	5.14	0.72	1.49
Verdaut im ganzen :	42.03	6.18	35.65	0.38	— 0.18
Verdauungskoeffizienten :	81.5%	73.6%	87.3%	34.6%	

## Periode XIV. Weizen, Hahn Nr. 22

60 g Weizen ... ..	51.60	8.40	40.79	1.10	1.31
13.03 g Exkrement ... ..	7.84	1.46	4.29	0.72	1.37
Verdaut im ganzen :	43.76	6.94	36.51	0.38	— 0.06
Verdauungskoeffizienten :	84.9%	82.6%	89.4%	34.6%	
„ im Durchschnitt :	<b>83.1%</b>	<b>77.9%</b>	<b>88.2%</b>	<b>31.8%</b>	



	Organische Substanz g	Ro- protein g	N-freie Extrakt- stoffe g	Rohfett g	Rohfaser g
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Hahn Nr. 24

60 g Weizen ... ..	51.60	8.40	40.79	1.10	1.31
12.87 g Exkrement ... ..	7.94	1.73	4.34	0.50	1.36
Verdaut im ganzen :	43.66	6.67	36.45	0.50	— 0.05
Verdauungskoeffizienten :	84.7%	79.4%	89.4%	54.5%	
„ im Durchschnitt :	<b>83.5%</b>	<b>78.9%</b>	<b>88.3%</b>	<b>44.5%</b>	

Periode IV. Gerste, Hahn Nr. 22

70 g Gerste ... ..	58.86	9.56	44.64	1.30	3.36
20.89 g Exkrement ... ..	15.31	2.33	8.91	0.55	3.52
Verdaut im ganzen :	43.55	7.23	35.73	0.75	— 0.15
Verdauungskoeffizienten :	74.0%	75.6%	80.1%	57.6%	

Hahn Nr. 24

70 g Gerste ... ..	58.86	9.56	44.64	1.30	3.36
20.40 g Exkrement ... ..	15.02	2.30	8.75	0.48	3.52
Verdaut im ganzen :	43.84	7.26	35.89	0.82	— 0.16
Verdauungskoeffizienten :	74.4%	76.0%	80.5%	63.0%	

Periode IX. Gerste, Hahn Nr. 22

70 g Gerste ... ..	58.86	9.56	44.64	1.30	3.36
21.45 g Exkrement ... ..	14.85	2.32	8.36	0.66	3.50
Verdaut im ganzen :	44.01	7.24	36.28	0.64	— 0.14
Verdauungskoeffizienten :	74.8%	76.0%	81.3%	49.2%	

Hahn Nr. 24

70 g Gerste ... ..	58.86	9.56	44.64	1.30	3.36
21.19 g Exkrement ... ..	14.32	2.24	8.21	0.51	3.36
Verdaut im ganzen :	44.54	7.32	36.43	0.79	0.00
Verdauungskoeffizienten :	75.8%	76.6%	81.6%	60.7%	

	Organische Substanz g	Roh- protein g	N-freie Extrakt- stoffe g	Rohfett g	Rohfaser g
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## Periode XI. Gerste, Hahn Nr. 22

70 g Gerste ... ..	58.86	9.56	44.64	1.30	3.36
24.42 g Exkrement ... ..	15.69	2.55	8.87	0.82	3.44
Verdaut im ganzen:	43.18	7.01	35.77	0.48	— 0.08
Verdauungskoeffizienten:	73.2%	73.4%	80.3%	46.9%	
„ im Durchschnitt:	<b>74.0%</b>	<b>75.0%</b>	<b>80.6%</b>	<b>51.2%</b>	

## Hahn Nr. 24

70 g Gerste ... ..	58.86	9.56	44.64	1.30	3.36
23.82 g Exkrement ... ..	15.54	2.22	9.27	0.63	3.41
Verdaut im ganzen:	43.32	7.34	35.36	0.66	— 0.05
Verdauungskoeffizienten:	73.6%	76.8%	79.4%	50.8%	
„ im Durchschnitt:	<b>74.6%</b>	<b>76.5%</b>	<b>80.6%</b>	<b>58.2%</b>	

## Periode II. Getrocknete Gemüse, Hahn Nr. 22

40 g Weizen ... ..	34.40	5.60	27.21	0.73	0.87
20 g ... ..	15.27	4.79	8.44	0.43	1.61
Gesamtverzehr:	49.67	10.39	35.65	1.16	2.48
19.89 g Exkrement ... ..	11.61	1.99	6.39	0.74	2.49
Verdaut im ganzen:	38.06	8.40	29.26	0.42	— 0.01
„ vom Weizen:	28.58	4.36	24.00	0.23	
„ vom Gemüse:	9.48	4.04	5.26	0.19	
Verdauungskoeffizienten:	<b>62.2%</b>	<b>84.3%</b>	<b>62.3%</b>	<b>44.1%</b>	

## Hahn Nr. 24

Gesamtverzehr wie Hahn Nr. 22:	49.67	10.39	35.65	1.16	2.48
19.60 g Exkrement ... ..	10.55	2.16	5.19	0.74	2.48
Verdaut im ganzen:	39.12	8.23	30.46	0.42	0.00
„ vom Weizen:	28.71	4.42	24.02	0.32	
„ vom Gemüse:	10.41	3.81	6.44	0.10	
Verdauungskoeffizienten:	<b>68.2%</b>	<b>79.5%</b>	<b>76.2%</b>	<b>10.0%</b>	

	Organische Substanz g	Roht- protein g	N-freie Extrakt- stoffe g	Rohtfett g	Rohtfaser g
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Periode XIII. Weizenkleie, Hahn Nr. 22

30 g Weizen ... ..	25.80	4.20	20.40	0.55	0.65
30 g Weizenkleie... ..	24.83	4.60	16.10	1.44	2.69
Gesamtverzehr :	50.63	8.80	36.50	1.99	3.34
22.25 g Exkrement ... ..	15.44	2.56	8.71	0.94	3.24
Verdaut im ganzen :	35.19	6.24	27.79	1.05	0.10
„ vom Weizen :	21.44	3.27	17.99	0.17	
„ von der Weizenkleie :	13.75	2.97	9.80	0.88	
Verdauungskoeffizienten :	<b>55.4%</b>	<b>64.6%</b>	<b>60.8%</b>	<b>61.1%</b>	

Hahn Nr. 24

Gesamtverzehr wie Hahn Nr. 22 :	50.63	8.80	36.50	1.99	3.34
21.99 g Exkrement ... ..	15.48	2.46	8.94	0.89	3.21
Verdaut im ganzen :	35.15	6.34	27.56	1.10	0.13
„ vom Weizen :	21.52	3.31	18.00	0.24	
„ von der Weizenkleie :	13.62	3.03	9.56	0.86	
Verdauungskoeffizienten :	<b>55.0%</b>	<b>65.9%</b>	<b>59.4%</b>	<b>59.8%</b>	

Periode XV. Sojabohnenkuchen, Hahn Nr. 22

18 g Weizen... ..	15.48	2.52	12.24	0.33	0.39
36 g Sojabohnenkuchen ... ..	29.55	15.07	9.99	2.78	1.71
Gesamtverzehr :	45.03	17.59	22.23	3.11	2.10
18.89 g Exkrement ... ..	9.36	3.38	3.48	0.33	2.17
Verdaut im ganzen :	35.67	14.21	18.75	2.78	— 0.07
„ vom Weizen :	12.85	1.96	10.79	0.10	
„ von Sojabohnenkuchen :	22.82	12.25	7.96	2.68	
Verdauungskoeffizienten :	<b>77.2%</b>	<b>81.3%</b>	<b>79.7%</b>	<b>81.2%</b>	

	Organische Substanz g	Roh- protein g	N-freie Extrakt- stoffe g	Rohfett g	Rohfaser g
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## Hahn Nr. 24

Gesamtverzehr wie Hahn Nr. 22 :	45.03	17.59	22.23	3.11	2.10
20.12 g Exkrement ... ..	10.17	2.96	4.79	0.25	2.18
Verdaut im ganzen :	34.86	14.63	17.44	2.86	— 0.08
„ vom Weizen :	12.91	1.99	10.80	0.15	
„ von Sojabohnenkuchen :	11.95	12.64	6.64	2.71	
Verdauungskoeffizienten :	<b>74.0%</b>	<b>83.9%</b>	<b>66.4%</b>	<b>82.1%</b>	

## Periode VI. Fischguano, Hahn Nr. 22

40 g Gerste ... ..	33.63	5.46	25.51	0.74	1.92
30 g Fischguano ... ..	22.97	18.00	0.85	4.10	—
Gesamtverzehr :	56.60	23.48	26.36	4.84	1.92
27.11 g Exkrement ... ..	11.80	3.55	5.68	0.54	2.02
Verdaut im ganzen :	44.80	19.93	20.68	4.30	— 0.10
„ von Gerste :	24.90	4.08	20.52	0.38	
„ „ Fischguano :	19.90	15.85	0.16	3.92	
Verdauungskoeffizienten :	<b>86.8%</b>	<b>87.8%</b>	<b>18.8%</b>	<b>95.7%</b>	

## Hahn Nr. 24

Gesamtverzehr wie Hahn Nr. 22 :	56.60	23.48	26.36	4.84	1.92
26.84 g Exkrement ... ..	11.38	2.97	6.26	0.33	1.84
Verdaut im ganzen :	45.22	20.51	20.10	4.51	0.08
„ von Gerste :	25.03	4.17	20.52	0.43	
„ „ Fischguano :	20.19	16.34	— 0.42	4.08	
Verdauungskoeffizienten :	<b>88.0%</b>	<b>90.9%</b>		<b>99.7%</b>	

## Periode VII. Getrockneter Fisch, Hahn Nr. 22

40 g Gerste ... ..	33.63	5.46	25.51	0.74	1.92
30 g Getrockneter Fisch ... ..	22.31	16.80	1.11	4.40	—
Gesamtverzehr :	55.94	22.26	26.62	5.14	1.92

	Organische Substanz g	Roh- protein g	N-freie Extrakt- stoffe g	Rohfett g	Rohfaser g
28.47 g Exkrement ... ..	12.60	4.08	6.02	0.44	2.05
Verdaut im ganzen:	43.34	18.18	20.60	4.70	— 0.13
„ von Gerste:	24.90	4.08	20.52	0.38	
„ von getrocknetem Fisch:	18.44	14.10	0.08	4.32	
Verdauungskoeffizienten:	<b>82.6%</b>	<b>84.0%</b>		<b>98.1%</b>	

Hahn Nr. 24

Gesamtverzehr wie Hahn Nr. 22:	55.94	22.26	26.62	5.14	1.92
27.30 g Exkrement ... ..	11.72	2.81	6.58	0.29	2.02
Verdaut im ganzen:	44.22	19.45	20.04	4.85	— 0.10
„ von Gerste:	25.03	4.17	20.52	0.43	
„ von getrocknetem Fisch:	19.19	15.28	— 0.48	4.42	
Verdauungskoeffizienten:	<b>86.0%</b>	<b>90.8%</b>		<b>100.0%</b>	

Periode VIII. Kartoffelpülpe, Hahn Nr. 22

$\frac{1}{3}$ der Futterration von Periode VII. ....	18.65	7.42	8.87	1.71	0.64
50 g Kartoffelpülpe ... ..	41.06	1.30	35.62	0.97	3.17
Gesamtverzehr:	59.71	8.72	44.49	2.68	3.81
26.60 g Exkrement ... ..	18.38	2.61	11.32	0.73	3.72
Verdaut im ganzen:	41.33	6.11	33.17	1.95	0.09
Verdaut vom Grundfutter:	14.45	6.06	6.87	1.57	
„ von der Kartoffelpülpe:	26.88	0.05	26.30	0.38	
Verdauungskoeffizienten:	<b>65.5%</b>		<b>73.0%</b>	<b>39.2%</b>	

Hahn Nr. 24

Gesamtverzehr wie Hahn Nr. 22:	59.71	8.72	44.49	2.68	3.81
26.70 g Exkrement ... ..	17.76	3.25	10.02	0.77	3.70
Verdaut im ganzen:	41.95	5.47	34.47	1.91	0.11
„ vom Grundfutter:	14.74	6.48	6.68	1.62	
„ von der Kartoffelpülpe:	27.21	— 1.01	27.79	0.29	
Verdauungskoeffizienten:	<b>66.2%</b>		<b>78.0%</b>	<b>29.2%</b>	

	Organische Substanz g	Roh- protein g	N-freie Extrakt- stoffe g	Rohfett g	Rohfaser g
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## Periode V. Reisfuttermehl, Hahn Nr. 22

40 g Gerste ... ..	33.62	5.46	25.51	0.74	1.92
40 g Reisfuttermehl ... ..	21.90	4.40	10.36	4.50	2.65
Gesamtverzehr :	55.52	9.86	35.87	5.24	4.57
41.33 g Exkrement ... ..	18.42	3.10	9.67	1.05	4.60
Verdaut im ganzen :	37.10	6.77	26.20	4.19	— 0.03
.. von Gerste :	24.90	4.08	20.52	0.38	
.. von Reisfuttermehl :	12.20	2.69	5.68	3.81	
Verdauungskoeffizienten :	<b>55.8%</b>	<b>61.0%</b>	<b>54.8%</b>	<b>84.6%</b>	

## Hahn Nr. 24

Gesamtverzehr wie Hahn Nr. 22 :	55.52	9.86	35.87	5.24	4.57
39.35 g Exkrement ... ..	17.52	2.68	9.55	0.75	4.57
Verdaut im ganzen :	38.00	7.18	26.32	4.49	0.00
.. von Gerste :	25.03	4.17	20.52	0.43	
.. von Reisfuttermehl :	12.97	3.01	5.80	4.06	
Verdauungskoeffizienten :	<b>59.2%</b>	<b>68.5%</b>	<b>56.0%</b>	<b>90.2%</b>	

## Periode X. Ungeschälter Reis, Hahn Nr. 22

60 g Ungeschälter Reis ... ..	48.98	6.12	37.50	0.72	4.64
17.65 g Exkrement ... ..	10.48	1.29	4.40	0.26	4.52
Verdaut im ganzen :	38.50	4.83	33.10	0.46	0.12
Verdauungskoeffizienten :	<b>78.6%</b>	<b>79.2%</b>	<b>88.2%</b>	<b>64.0%</b>	

## Hahn Nr. 24

60 g Ungeschälter Reis ... ..	48.98	6.12	37.50	0.72	4.64
19.45 g Exkrement ... ..	10.61	1.36	4.34	0.21	4.71
Verdaut im ganzen :	38.37	4.76	33.16	0.51	— 0.07
Verdauungskoeffizienten :	<b>78.4%</b>	<b>78.0%</b>	<b>88.5%</b>	<b>70.8%</b>	

	Organische Substanz g	Roh- protein g	<sup>3</sup> N-freie Extrakt- stoffe g	Rohfett g	Rohfaser g
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Periode XII. Geschälter Reis u. Kleeheu, Hahn Nr. 22

50 g Geschälter Reis ... ..	43.18	4.87	36.84	1.09	0.38
20 g Kleeheu ... ..	15.31	5.23	7.36	0.48	2.24
Gesamtverzehr:	58.49	10.10	44.20	1.57	2.62
19.18 g Exkrement ... ..	10.83	2.28	5.05	0.86	2.66
Verdaut im ganzen:	47.66	7.82	39.15	0.71	— 0.04
Verdauungskoeffizienten:	<b>81.6%</b>	<b>77.4%</b>	<b>88.5%</b>	<b>45.2%</b>	

Hahn Nr. 24

Gesamtverzehr wie Hahn Nr. 22:	58.49	10.10	44.20	1.57	2.62
19.64 g Exkrement ... ..	11.13	2.26	5.34	0.82	2.70
Verdaut im ganzen:	47.36	7.84	38.86	0.75	— 0.08
Verdauungskoeffizienten:	<b>81.0%</b>	<b>77.6%</b>	<b>87.8%</b>	<b>47.8%</b>	

Vorstehende Berechnungen zeigen, dass die Verdaulichkeit für die Einzelbestandteile bei beiden Hähnen in jedem Versuchsabschnitte befriedigend gut übereinstimmen. Bezüglich der Rohfaser machte sich jedoch in dieser ersten Versuchsreihe sowohl, als auch in der zweiten fast immer eine so geringe Ausnutzung geltend, dass es zweifelhaft ist, ob die Rohfaser tatsächlich durch die Hühner verdaut werden kann. In einigen Fällen wurde sogar eine Minusverdauung zu einem, wenn auch sehr geringen Prozentsatz beobachtet, der aber innerhalb der Fehlergrenzen liegt, die bei solchen Versuchen nicht zu vermeiden sind. Da das Futter jedenfalls bei den Vögeln durchaus viel kürzere Zeit in den Verdauungsorganen sich aufhält als beim Säugetiere und rascher durch den Körper hindurch geht, sogar manchmal schon in einigen Stunden nach der Verfütterung die Ausscheidung beobachtet wird, so wäre es möglich, dass eine Einwirkung der Bakterien fast gar nicht stattfindet.

Bei Untersuchungen von *Weiske* und *Küster* mit Hühnern, welchen Futtermischung unter Zusatz von Papier, Baumwolle etc. verabreicht wurde, stellte sich heraus, dass die Rohfaser von der genannten Tiergattung stets nicht verdaut wurde. *Fr. Jaugl* (17) hat auch b Fütterungsversuchen bemerkt, dass die Rohfaser des Hirses von Huhn, Puter, Ente und Gans gar nicht verdaut wurde. Im Gegensatz wurde jedoch von *Brown*, *Kalugin* und anderen Forschern mehr oder weniger positive Verdauung der Rohfaser durch Hühner bei einigen Körnerfütterarten beobachtet, deren Verdauungskoeffizienten jedoch ziemlich starke Schwankungen zeigten, die bald gross bald klein und oft starke Minusverdauung zeigten. Bei den Versuchen von *W. Völtz* und *G. Yakuwa* mit Kartoffel, Hafer und Roggen zeigten die Verdauungskoeffizienten der Rohfaser auch geringen Prozentsatz.

*I. Kalugin* behauptete, dass die Rohfaser sowie auch Rohprotein im Futter durch Zugabe von Sand und Kohlen von Hühnern besser verdaut werden können. Der Sand kann freilich die Zerkleinerung der harten Futterkörner erleichtern, aber es ist zweifelhaft für eine günstige Wirkung auf die Verdauung der Rohfaser, besonders wenn die Hühner mit geschrotetem oder gemahlenem Futter versehen werden, was bei unserem Versuche immer der Fall ist.

Um hierüber ins Klare zu kommen, habe ich von neuem einige Versuche mit zwei Hähnen, bezeichnet Nr. 39 und Nr. 40 ausgeführt. In dem ersten Versuche wurden den Hühnern zerschnittene Papierzellulose neben Grundfutter verabreicht, welche aus naheliegenden Gründen viel höher verdaulich sein kann, als die in gewöhnlichen Futtermitteln enthaltene Rohfaser. *O. Kellner* (18) und *F. Lehmann* (19) haben schon nachgewiesen, dass der gebleichte Strohstoff der Papierfabrikation, der durch Kochen von Stroh mit Lauge unter starkem Druck gewonnen wird, von den Wiederkäuern in sehr beachtenswertem Umfange aufgelöst wird, weil durch die erwähnte Behandlung die inkrustierenden, die Verdauung hemmenden Substanzen aufgelöst und entfernt werden. Aus den Versuchen von *G. Fingerling* (20) geht hervor, dass reine Zellulose von den Schweinen ebenso hoch verdaut wird wie von Wiederkäuern, während bei verholzter



und mit inkrustierenden Stoffen durchsetzter Zellulose die Rohfaserverdauung stark zurücktritt. Ich wollte zwar den Hühnern möglichst grosse Menge von Zellulose verabreichen, aber sie konnten wegen deren grossem Volumen nur 2.5 g derselben vertragen.

Die Futterration und der Gehalt des Futtermittels an Rohfaser in der ersten Periode waren folgende:

	Futter		Rohfaser	
{	37.50 g geschälter Reis		1.16%	0.43 g
	35.20 „ Weizen		2.19	0.77
	1.50 „ Aleuronat		—	—
	0.75 „ getrocknete Gemüse		9.46	0.07
	2.5 „ Papierzellulose		81.05%	2.03 g
			}	1.27 g

In der zweiten Periode wurde nur das Grundfutter zum Verzehr gebracht.

Nachdem die 6tägige vorbereitende Fütterung vollendet war, folgte die eigentliche, die 7 Tage dauerte. Die Exkrementmengen (lufttrocken) waren folgende:

Periode I. Papierzusatz			Periode II. Ohne Papierzusatz		
Datum 1914	Hahn Nr. 39	Hahn Nr. 40	Datum 1914	Hahn Nr. 39	Hahn Nr. 40
Mai			Mai		
18.	15.05 g	15.01 „	31.	13.75 g	13.58 g
19.	16.21 „	14.73 „	Juni		
20.	12.00 „	15.69 „	1.	14.57 „	13.68 „
21.	17.23 „	16.19 „	2.	13.59 „	13.82 „
22.	15.62 „	16.19 „	3.	13.95 „	13.31 „
23.	14.55 „	15.10 „	4.	12.74 „	15.13 „
24.	16.55 „	17.64 „	5.	12.56 „	13.40 „
			6.	13.99 „	12.90 „
Im Mittel	<b>15.31 „</b>	<b>15.79 „</b>	Im Mittel	<b>13.60 „</b>	<b>13.59 „</b>

Der Rohfasergehalt des Exkrementes war in der ersten Periode 20.63% bei Hahn Nr. 39, 20.84% bei Hahn Nr. 40 und in der zweiten Periode 8.94% bei Hahn Nr. 39, 0.14% bei Hahn Nr. 40. Die Bilanz der Rohfaser ist aus folgender Zusammenstellung ersichtlich:

Periode I. Papierzusatz					
Grundfutter...	...	...	...	1.27 g	Rohfaser
Papierzellulose	...	...	...	2.03 g	„
Summe	...	...	...	3.30 g	„
Hahn Nr. 39			Hahn Nr. 40		
Einnahme...	...	3.30 g	Rohfaser	3.30 g	Rohfaser
Ausgabe	...	3.26 „	„	3.29 „	„
Differenz	...	0.04 „	„	0.01 „	„
Periode II. Ohne Papierzusatz					
Grundfutter...	...	...	...	1.27 g	Rohfaser
Hahn Nr. 39			Hahn Nr. 40		
Einnahme...	...	1.27 g	Rohfaser	1.27 g	Rohfaser
Ausgabe	...	1.22 „	„	1.24 „	„
Differenz	...	0.05 „	„	0.03 „	„

Aus diesen Zahlen erkennen wir, dass die Hühner weder die in Papier enthaltene Rohfaser, noch die in andern Futtermitteln enthaltene resorbierten, welche aber von den Säugetieren sehr gut ausgenutzt werden kann. Mikroskopische Untersuchung ergab, dass keine bemerkbare Veränderung in Bezug auf die Rohfaser wahrnehmbar war, abgesehen davon, dass nur ein kleiner Teil der Papierfaser etwas gequollen war.

Um nun eine günstige Wirkung von Sand auf die Verdauung der Rohfaser zu untersuchen, habe ich noch einen Versuch mit zwei Hühnern, die, mit Nr. 29 und Nr. 30 bezeichnet, schon ein paar Monat lang keinen Sand erhalten hatten, angestellt.

Das in einer ersten Periode verzehrte Grundfutter bestand pro Tag und Kopf aus 50 g geschrotener Gerste und 25 g Weizenkleie. In einer zweiten Periode wurde erbsengrosser Quarzsand ad libitum neben diesem Grundfutter zum Verzehr gebracht. Die vorbereitende Fütterung sowie auch die eigentliche dauerte so lange wie beim vorangegangenen Versuche.

Die Futterration und der Gehalt des Futtermittels an Rohfaser waren folgende:

Futter	Rohfaser	
50 g geschälter Reis	4.91%	2.45 g
25 „ Weizenkleie	7.26 „	1.82 „
	Summe	4.27 „

Die Exkrementmengen (lufttrocken) waren folgende:

Periode I. Ohne Quarzsand			Periode II. Quarzsandzusatz		
Datum 1914	Hahn Nr. 29	Hahn Nr. 30	Datum 1914	Hahn Nr. 29	Hahn Nr. 30
September			September		
12.	21.71 g	24.15 g	27.	22.76 g	25.11 g
13.	24.07 „	27.73 „	28.	35.83 „	23.56 „
14.	29.41 „	26.65 „	29.	21.43 „	21.63 „
15.	27.27 „	24.50 „	30.	24.55 „	24.92 „
16.	25.70 „	25.38 „	Oktober		
17.	27.73 „	24.33 „	1.	24.24 „	22.70 „
18.	25.68 „	25.25 „	2.	22.60 „	22.25 „
19.	27.40 „	29.06 „	3.	22.92 „	21.91 „
			4.	21.99 „	26.24 „
Im Mittel	<b>26.12 „</b>	<b>25.88 „</b>	Im Mittel	<b>23.29 „</b>	<b>23.54 „</b>

Der Rohfasergehalt des Exkrementes war in der ersten Periode 16.58% bei Hahn Nr. 29, 16.60% bei Hahn Nr. 30, und in der zweiten Periode 18.30% bei Hahn Nr. 29, 18.27% bei Hahn Nr. 30. Aus dem

Gehalt des Futters sowie Exkrementes an Rohfaser wird die Bilanz der letzteren wie folgt berechnet:

Periode I. Grundfutter					
Hahn Nr. 29			Hahn Nr. 30		
Einnahme...	...	4.27 g	Rohfaser		4.27 g Rohfaser
Ausgabe ...	...	4.33 „	„		4.30 „ „
Differenz ...		-0.06 „	„		-0.03 „ „
Periode II. Quarzsandzusatz					
Hahn Nr. 29			Hahn Nr. 30		
Einnahme...	...	4.27 g	Rohfaser		4.27 g Rohfaser
Ausgabe ...	...	4.27 „	„		4.30 „ „
Differenz ...		0.00 „	„		-0.03 „ „

Vorstehende Zahlen zeigen, dass der Quarzsand keine spezifische Wirkung auf die Verdauung der Rohfaser ausübt.

Die Schwankungen, welche bei der Bilanz der Rohfaser sowohl in vorliegendem als auch in vorangegangenen Versuchen beobachtet wurden, müssen jedoch als sehr gering bezeichnet werden, wenn man bedenkt, dass alle Versuchsfehler bei der Kotabgrenzung, der Mischung und Untersuchung des Kotes dem verdaulichen Teile des Futters unvermeidlich zur Last geschrieben werden. Insbesondere besitzt noch das Verfahren der quantitativen Bestimmung der Rohfaser keine sehr grosse Schärfe. Wenn man daher ca. 0.3—0.4% für analytische Fehler zur Rohfaserbestimmung gestattet, so könnte schon dadurch die bei der Bilanz ermittelte Differenz beinahe gedeckt werden, welche angeblich als verdaulich ersehen wird. Ich möchte nunmehr aus sämtlichen Fütterungsversuchen schliessen, dass die Rohfaser durch die Hühner entweder nur zu einem sehr geringen Prozentsatz oder überhaupt nicht verdaut wird, und dass man daher die Rohfaser bei der Futterberechnung als unverdaulich ausser acht lassen kann. Dass die Plus- sowie Minus-verdauung zu nicht unbedeutendem Prozentsatz für die Rohfaser von einigen Forschern mitgeteilt worden ist, ist wahrscheinlich der Unregelmässigkeit der

Futteraufnahme und der Ausscheidung, oder der ungenügenden Dauer der Vor- und Hauptversuche zuzuschreiben. Zwar nehmen die Hühner nicht selten gern sehr rohfaserreiche Futtermittel auf, aber sie wird zweifellos bloss als Entleerungsmaterial der Verdauungsorgane benutzt werden.

7. *Der Vergleich der vor und nach der Operation der Hühner ausgeführten Fütterungsversuche.*

Ich möchte hier wieder auf die Verdaulichkeit der Nährstoffbestandteile von einzelnen Futtermitteln zurückkommen, welche bei der ersten sowie in der zweiten Versuchsreihe untersucht worden sind. Um bei der Erörterung von Einzelheiten einen besseren Überblick zu gewinnen, habe ich in der nächsten Tabelle die mit den nicht operierten Hühnern ermittelten Zahlen sowie die entsprechenden mit dem operierten Hahn zusammengestellt:

		Organische Substanz %	Rob- protein %	N-freie Extrakt- stoffe %	Roifett %
Weizen					
Normaler	Hahn Nr. 24 ... ..	83.5	78.9	88.3	44.5
	„ Nr. 22 ... ..	83.1	77.9	88.2	31.8
Operierter	„ Nr. 22 ... ..	86.2	80.0	91.3	43.0
	Im Mittel ... ..	<b>84.3</b>	<b>78.9</b>	<b>89.3</b>	<b>39.8</b>
Gerste					
Normaler	Hahn Nr. 24 ... ..	74.6	76.5	80.6	58.2
	„ Nr. 22 ... ..	74.0	75.0	80.6	51.2
Operierter	„ Nr. 22 ... ..	77.5	73.8	85.3	34.7
	Im Mittel ... ..	<b>75.4</b>	<b>75.1</b>	<b>82.2</b>	<b>48.0</b>
Weizenkleie					
Normaler	Hahn Nr. 24 ... ..	55.0	65.8	59.4	59.8
	„ Nr. 22 ... ..	55.4	64.6	60.8	61.1
Operierter	„ Nr. 22 ... ..	55.5	62.4	63.4	45.8
	Im Mittel ... ..	<b>55.3</b>	<b>64.3</b>	<b>61.2</b>	<b>55.6</b>

		Organische Substanz %	Roh- protein %	N-freie Extrakt- stoffe %	Rohfett %
<b>Reisfuttermehl</b>					
Normaler	Hahn Nr. 24 ... ..	59.2	68.5	56.0	90.2
	„ Nr. 22 ... ..	55.8	61.0	54.8	84.6
Operierter	„ Nr. 22 ... ..	63.7	71.1	63.7	88.4
	Im Mittel ... ..	<b>59.7</b>	<b>66.9</b>	<b>58.2</b>	<b>87.7</b>
<b>Ungeschälter Reis</b>					
Normaler	Hahn Nr. 24 ... ..	78.4	78.0	88.5	70.8
	„ Nr. 22 ... ..	78.6	79.2	88.2	64.0
Operierter	„ Nr. 22 ... ..	77.0	73.5	87.7	57.5
	Im Mittel ... ..	<b>78.0</b>	<b>76.9</b>	<b>88.1</b>	<b>64.1</b>
<b>Sojabohnenkuchen</b>					
Normaler	Hahn Nr. 24 ... ..	74.0	83.9	66.4	82.1
	„ Nr. 22 ... ..	77.2	81.3	79.7	81.2
Operierter	„ Nr. 22 ... ..	78.6	84.9	79.7	89.0
	Im Mittel ... ..	<b>76.6</b>	<b>83.4</b>	<b>75.3</b>	<b>84.1</b>
<b>Fischguano</b>					
Normaler	Hahn Nr. 24 ... ..	88.0	90.6	—	99.7
	„ Nr. 22 ... ..	86.8	87.8	—	95.7
Operierter	„ Nr. 22 ... ..	91.9	93.3	—	99.2
	Im Mittel ... ..	<b>88.9</b>	<b>90.6</b>	—	<b>98.2</b>
<b>Kartoffelplülpe</b>					
Normaler	Hahn Nr. 24 ... ..	66.2	—	78.0	29.2
	„ Nr. 22 ... ..	65.5	—	73.0	39.2
Operierter	„ Nr. 22 ... ..	66.6	—	80.9	5.6
	Im Mittel ... ..	<b>66.1</b>	—	<b>77.3</b>	<b>27.0</b>
<b>Geschälter Reis u. Kleheu</b>					
Normaler	Hahn Nr. 24 ... ..	81.0	77.6	87.8	47.8
	„ Nr. 22 ... ..	81.6	77.4	88.5	45.2
Operierter	„ Nr. 22 ... ..	82.9	78.4	90.5	23.4
	Im Mittel ... ..	<b>81.8</b>	<b>77.8</b>	<b>88.9</b>	<b>38.8</b>

Wie aus vorstehenden Zahlen ersichtlich ist, weisen die Werte für die Verdauungskoeffizienten der einzelnen Nährstoffgruppen, welche bei beiden Versuchsreihen mit den normalen Hähnen sowie auch mit einem operierten ermittelt worden sind, keine allzu grossen Unterschiede auf. Die Verdaulichkeit von Weizen, Gerste, eines Gemisches von Weizen und Weizenkleie bei mehrfach wiederholten Versuchen und die einer Futtermischung von geschältem Reis und Klebeumehl sowie auch von Weizen und Sojabohnenkuchen stimmen vor und nach der Operation mit einander—nur von Rohfett abgesehen—sehr gut überein.

Die Unterschiede bei dem Fette müssen aber höchstwahrscheinlich der Beimischung ätherlöslicher Stoffwechselprodukte zum Kot zugeschrieben werden.

Bei beiden Futtermitteln von ungeschältem Reis und Fischmehl zeigt sich ein, wenn auch nicht bedeutender, Unterschied in Bezug auf das Rohprotein, sonst eine befriedigende Übereinstimmung. Ziemlich stark weichen die Verdaulichkeit der einzelnen Bestandteile von Kartoffelpülpel und Reisfuttermehl bei beiden Versuchsreihen ab; indessen ist die Differenz bei der ersteren wahrscheinlich auf bedeutende Unterschiede des Grundfutters, und die beim letztern auf Verschiedenheit der Beschaffenheit, die auch aus der chemischen Zusammensetzung erkannt wird, zurückzuführen.

Jedenfalls müssen die Verdauungskoeffizienten der verschiedenen Futtermittel beim Vergleich zwischen beiden Versuchsreihen im allgemeinen als sehr gut übereinstimmend bezeichnet werden. Wir können daher schliessen, dass die verdauliche Nährstoffmenge eines den Hühnern darzubietenden Futtermittels nach dem oben erwähnten Verfahren mit den normalen Hühnern verhältnismässig einfach und genau genug ermittelt werden kann, ohne dass man dabei ein mit künstlichem After versehenes Huhn zuzubereiten braucht, welches immer aufmerksame Sorge für Pflege, besonders für Kotsammlung bei einer rohfaserreichen Ernährung braucht, ohne dass man leicht einen grossen Fehler beim Ausnutzungsversuche begeht.

8. *Kalorimetrische Untersuchungen über die Futtermittel und Exkremente.*

Der Wärmewert pro Gramm des Futtermittels in der ersten Versuchsreihe ist in folgender Tabelle zusammengestellt:

Futter	
Gerste ... .. 3.964	Kartoffelpülze ... .. 3.567
Weizen ... .. 3.907	Getrockneter Fisch ... .. 4.966
Ungeschälter Reis... .. 3.762	Fischguano ... .. 4.937
Weizenkleie ... .. 4.036	Sojabohnenkuchen ... .. 4.692
Getrocknete Gemüse ... .. 3.439	Geschälter Reis ... .. 3.689
Reisfuttermehl ... .. 3.251	Kleeheu... .. 3.657

Der Wärmewert des Kotes, welcher aus dem des Exkrementes und der Harnorganischensubstanzen (pro Gramm 2.90 Kal) berechnet wurde, ist folgender:

Hahn Nr. 22.

	1g Exkrement Kal	Harn-Org. Substanz %	Harn in 1g Exkrement Kal	Kot in 1g Exkrement Kal
Periode I. ... ..	3.701	22.10	0.640	3.061
„ II. ... ..	3.407	17.57	0.510	2.897
„ III. ... ..	3.934	19.46	0.564	3.370
„ IV. ... ..	3.852	11.12	0.322	3.530
„ V. ... ..	2.517	7.04	0.204	2.313
„ VI. ... ..	3.158	33.74	0.980	2.178
„ VII. ... ..	3.078	27.67	0.803	2.271
„ VIII. ... ..	3.267	9.91	0.288	2.979
„ IX. ... ..	3.798	13.43	0.389	3.409
„ X. ... ..	3.251	11.67	0.338	2.913
„ XI. ... ..	3.927	15.45	0.448	3.479
„ XII. ... ..	3.619	17.60	0.510	3.109
„ XIII. ... ..	3.870	10.46	0.303	3.567
„ XIV. ... ..	3.707	20.77	0.602	3.105
„ XV. ... ..	3.011	30.55	0.889	2.722



Hahn Nr. 24.

	1g Exkrement Kal	Harn-Org. Substanz %	Harn in 1g Exkrement Kal	Kot in 1g Exkrement Kal
Periode I. ... ..	3.657	24.52	0.711	2.946
„ II. ... ..	3.466	21.65	0.628	2.838
„ III. ... ..	4.055	21.06	0.611	3.444
„ IV. ... ..	3.979	11.93	0.346	3.633
„ V. ... ..	3.488	7.76	0.225	2.263
„ VI. ... ..	3.104	32.18	0.933	2.171
„ VII. ... ..	2.992	28.46	0.825	2.167
„ VIII. ... ..	3.400	8.31	0.241	3.159
„ IX. ... ..	3.812	15.17	0.440	3.372
„ X. ... ..	3.162	17.21	0.499	2.668
„ XI. ... ..	3.936	18.09	0.525	3.411
„ XII. ... ..	3.624	16.56	0.480	3.144
„ XIII. ... ..	3.775	10.86	0.315	3.460
„ XIV. ... ..	3.678	20.38	0.591	3.087
„ XV. ... ..	3.477	31.46	0.912	2.585

Der Kaloriewert für die Tagesmenge der verdauten organischen Substanzen und derselbe in Prozenten des gesamten Wärmewertes der Futterration sind folgende:

	Futterration	Versuchs- hahn	Exkrement- menge g	Einnahme im Futter Kal	Ausgabe im Köte Kal	Wärmewert der verd. org. Substanz Kal	desgl. in Prozenten des Wärmewertes vom Futter %
Periode I.	60 g Weizen .....	Nr. 22	14.59	234.4	44.7	189.7	80.9
		Nr. 24	14.01	234.4	41.3	193.1	82.4
„ II.	40 g Weizen .....	Nr. 22	19.89	215.1	57.6	157.5	73.3
		Nr. 24	19.60	215.1	55.6	159.5	74.2
„ III.	60 g Weizen .....	Nr. 22	15.10	234.4	50.9	183.5	78.3
		Nr. 24	14.74	234.4	50.8	183.6	78.3
„ IV.	70 g Gerste .....	Nr. 22	20.89	277.5	73.7	203.8	73.5
		Nr. 24	20.40	277.5	74.1	203.4	73.3

	Futtermitteln	Versuchs- hahn	Exkrement- menge g	Einnahme im Futter Kal	Ausgabe im Kote Kal	Wärmewert der verd. org. Substanz Kal	desgl. in Prozenten des Wärmewertes vom Futter %						
Periode V.	40 g Gerste .....	} Nr. 22	41.33	288.6	95.6	193.0	66.9						
	40 g Reisfuttermehl							} Nr. 24	39.35	288.6	89.0	199.6	69.2
„ VI.	40 g Gerste .....	} Nr. 22	21.71	306.7	59.0	247.7	85.8						
	30 g getrock. Fisch							} Nr. 24	26.84	306.7	58.3	248.4	81.0
„ VII.	40 g Gerste .....	} Nr. 22	28.47	307.6	64.7	242.9	79.0						
	30 g getrock. Fisch							} Nr. 24	27.30	307.6	59.2	248.4	80.8
„ VIII.	13.33 g Gerste ...	} Nr. 22	26.60	281.4	79.2	202.2	71.9						
	10 g getrock. Fisch							} Nr. 24	26.70	281.4	84.3	197.1	70.1
	50 g Kartoffelpülpe												
„ IX.	70 g Gerste .....	} Nr. 22	21.45	277.5	73.1	204.4	73.7						
								} Nr. 24	21.19	277.5	71.4	206.1	74.2
„ X.	60 g Ungeschälter Reis.....	} Nr. 22	17.65	225.7	51.4	174.3	77.3						
								} Nr. 24	19.45	225.7	51.9	173.8	77.0
„ XI.	70 g Gerste .....	} Nr. 22	24.42	277.5	84.9	192.6	69.5						
								} Nr. 24	23.92	277.5	81.6	195.9	70.6
„ XII.	50 g geschälter Reis	} Nr. 22	19.98	257.6	59.6	198.0	76.9						
	20 g Kleeheu .....							} Nr. 24	19.64	257.6	61.7	195.9	76.0
„ XIII.	30 g Weizen.....	} Nr. 22	22.25	238.3	79.4	158.0	66.7						
	30 g Weizenkleie...							} Nr. 24	21.99	238.3	76.1	162.2	68.1
„ XIV.	60 g Weizen.....	} Nr. 22	13.03	234.4	40.4	194.0	82.8						
	18 g Weizen.....							} Nr. 24	12.87	234.4	39.7	194.7	83.0
„ XV.	36 g Sojabohnen- kuchen.....	} Nr. 22	18.89	239.2	51.4	187.8	78.5						
								} Nr. 24	20.12	239.2	52.0	187.2	78.3

Wenn man nun vorstehende Zahlen, die also Durchschnittszahlen bei wiederholten Versuchen sind, mit den entsprechenden beim operierten Huhn sowie auch mit den Verdauungskoeffizienten der organischen Substanz vergleicht, so ergibt sich folgendes:

	Wärmewert der verdauten organischen Substanz in Prozenten des Wärmewertes vom verzehrten Futter			Verdauungs- koeffizienten
	Hahn Nr. 24 (normal)	Hahn Nr. 22 (normal)	Hahn Nr. 22 (operiert)	%
Gerste... ..	72.7	72.2	74.8	75.3
Weizen ... ..	81.2	80.7	84.1	84.3
Gerste-Fischguano ... ..	81.0	80.8	83.5	80.9
Weizen-Weizenkleie ... ..	68.0	67.0	69.7	70.0
Ungeschälter Reis ... ..	77.0	77.3	74.0	78.0
Geschälter Reis-Kleeheu ... ..	76.0	76.9	79.0	81.8
Weizen-Sojabohnenkuchen ...	78.3	78.5	81.7	79.3

Es ist aus obigen Zahlen ersichtlich, dass beim Vergleich der beiden Versuchsreihen keine grossen Unterschiede sich finden und dass der Prozentsatz des Wärmewertes der verdauten organischen Substanz den Verdauungskoeffizienten der organischen Substanz immer beinahe gleich kommt. Die Wärmewerte der verdauten organischen Substanzen nach unserem Verfahren mit dem normalen Huhn sind verhältnismässig einfach und genau genug zu ermitteln.

9. Zusammenstellung der Ergebnisse.

Die Verdaulichkeit der Futtermittel kann bei Hühnern wegen der gemeinsamen Ausscheidung des Kotes und des Harnes nicht so leicht wie bei Säugetieren ermittelt werden.

Ich habe daher eingehende Untersuchungen über die Exkremeute von einem Hahn mit Anus praeternaturalis, sowie auch mit normalen Hühnern ausgeführt. Die Versuchsergebnisse zeigen, dass der Gesamtstickstoff des Harnes mit dem Wert, welchen man erhält, wenn man die Summe von Harnsäure und Harnammoniak mit 114.6% multipliziert, fast ohne grossen Unterschied übereinstimmt. Ferner dass die organischen Substanzen des Harnes dem Multiplizieren des Harnstickstoffs mit 3.26, die Fette dem 1.8 Prozentsatz der organischen Substanzen entsprechen, und dass der Kaloriewert pro Gramm der organischen

Substanzen vom Harn 2.90 Kal beträgt. Aus diesen Zahlen kann man die Verdaulichkeit der Futtermittel aus dem Exkrementgemenge bei normalen Hühnern mit genügender Genauigkeit ermitteln.

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Anhang I. I. Versuchsreihe

Periode I. Weizen

Hahn Nr. 22, Lebendgewicht 1.85 Kg

Hahn Nr. 24, Lebendgewicht 1.85 Kg

Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)	Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)
6. August 1911.	14.58 g	13.26 g	10. August 1911.	14.64	13.69
7. „ „	15.60	15.81	11. „ „	14.24	12.53
8. „ „	14.79	13.99	12. „ „	13.27	14.47
9. „ „	15.00	14.35	Im Mittel	<b>14.59</b>	<b>14.01</b>

Periode II. Getrocknete Gemüse

Hahn Nr. 22, Lebendgewicht 1.85 Kg

Hahn Nr. 24, Lebendgewicht 1.97 Kg

Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)	Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)
30. August 1911.	21.04	19.29	3. September 1911.	16.86	20.43
31. „ „	21.17	18.87	4. „ „	21.82	18.75
1. September „	20.48	18.79	5. „ „	15.77	21.80
2. „ „	22.09	19.28	Im Mittel	<b>19.89</b>	<b>18.60</b>

Periode III. Weizen

Hahn Nr. 22, Lebendgewicht 1.88 Kg

Hahn Nr. 24, Lebendgewicht 1.97 Kg

Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)	Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)
28. September 1911.	14.89	13.87	2. Oktober 1911.	15.34	14.80
29. „ „	15.20	14.48	3. „ „	14.44	15.06
30. „ „	15.52	15.42	4. „ „	15.22	15.05
1. Oktober 1911.	15.03	14.50	Im Mittel	<b>15.10</b>	<b>14.74</b>

## Periode IV. Gerste

Hahn Nr. 22, Lebendgewicht 1.93 Kg

Hahn Nr. 24, Lebendgewicht 2.05 Kg.

Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)	Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)
14. October 1911.	19.90	19.03	18. Oktober 1911.	21.92	21.59
15. „ „	20.56	19.65	19. „ „	20.29	19.75
16. „ „	21.36	20.82	20. „ „	22.10	21.42
17. „ „	19.87	20.53	Im Mittel	<b>20.87</b>	<b>20.40</b>

## Periode V. Reisuftermehl

Hahn Nr. 22, Lebendgewicht 1.97 Kg

Hahn Nr. 24, Lebendgewicht 2.10 Kg

Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 22 Exkrement (lufttrocken)	Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 22 Exkrement (lufttrocken)
27. October 1911.	39.17 g	37.34 g	31. Oktober 1911.	38.29 g	38.70 g
28. „ „	39.19	39.84	1. November „	37.08	37.90
29. „ „	47.61	39.93	2. „ „	41.91	40.99
30. „ „	46.05	40.73	Im Mittel	<b>41.33</b>	<b>39.35</b>

## Periode VI. Fischguano

Hahn Nr. 22, Lebendgewicht 2.12 Kg

Hahn Nr. 24, Lebendgewicht 2.24 Kg

Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)	Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)
9. November. 1911.	25.66 g	23.44 g	13. November 1911.	27.51 g	26.24 g
10. „ „	25.93	26.62	14. „ „	27.54	28.98
11. „ „	26.19	25.50	15. „ „	28.87	30.19
12. „ „	28.04	26.89	Im Mittel	<b>27.11</b>	<b>26.84</b>

Periode VII. Getrocknete Fisch

Hahn Nr. 22, Lebendgewicht 2.17 Kg

Hahn Nr. 24, Lebendgewicht 2.28 Kg

Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)	Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)
24. November 1911.	31.15 g	26.86 g	28. November 1911.	27.39 g	26.75 g
25. „ „	29.42	28.37	29. „ „	27.00	27.91
26. „ „	27.48	26.17	30. „ „	27.12	27.54
27. „ „	29.71	27.52	Im Mittel	<b>28.47</b>	<b>27.30</b>

Periode VIII. Kartoffelpülpe

Hahn Nr. 22, Lebendgewicht 2.17 Kg

Hahn Nr. 24, Lebendgewicht 2.31 Kg

Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)	Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)
7. Dezember 1911.	26.59 g	28.73 g	11. Dezember 1911.	28.30 g	26.34 g
8. „ „	26.35	26.77	12. „ „	24.50	25.65
9. „ „	27.14	28.06	13. „ „	29.63	26.07
10. „ „	23.74	25.31	Im Mittel	<b>26.60</b>	<b>26.70</b>

Periode IX. Gerste

Hahn Nr. 22, Lebendgewicht 2.22 Kg

Hahn Nr. 24, Lebendgewicht 2.37 Kg

Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)	Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)
19. Dezember 1911.	20.74 g	21.38 g	23. Dezember 1911.	21.28 g	20.86 g
20. „ „	21.70	20.39	24. „ „	20.72	21.28
21. „ „	19.58	20.74	25. „ „	22.73	22.89
22. „ „	23.89	20.83	Im Mittel	<b>21.45</b>	<b>21.19</b>

## Periode X. Ungeschälter Reis

Hahn Nr. 22, Lebendgewicht 2.27 Kg

Hahn Nr. 24, Lebendgewicht 2.455 Kg

Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)	Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)
2. Januar 1912.	19.73 g	19.76 g	6. Januar 1912.	15.60 g	19.20 g
3. " "	17.07	17.73	7. " "	17.11	19.27
4. " "	17.10	19.62	8. " "	17.25	28.19
5. " "	19.62	23.40	Im Mittel	<b>17.65</b>	<b>19.45</b>

## Periode XI. Gerste

Hahn Nr. 22, Lebendgewicht 1.31 Kg

Hahn Nr. 24, Lebendgewicht 2.49 Kg

Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)	Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)
16. Januar 1912.	23.54 g	21.49 g	20. Januar 1912.	22.46 g	24.95 g
17. " "	23.59	22.50	21. " "	27.11	27.20
18. " "	22.22	20.78	22. " "	29.49	28.49
19. " "	22.52	21.34	Im Mittel	<b>24.42</b>	<b>23.82</b>

## Periode XII. Geschälter Reis, Kleehen

Hahn Nr. 22, Lebendgewicht 2.35 Kg

Hahn Nr. 24, Lebendgewicht 2.50 Kg

Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)	Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)
1. Februar 1912.	18.71 g	16.08 g	5. Februar 1912.	18.74 g	20.50 g
2. " "	19.64	18.60	6. " "	19.82	20.20
3. " "	18.60	19.17	7. " "	19.10	20.60
4. " "	19.64	19.08	Im Mittel	<b>19.18</b>	<b>19.64</b>



Periode XIII. Weizenkleie

Hahn Nr. 22, Lebendgewicht 2.30 Kg

Hahn Nr. 24, Lebendgewicht 2.43 Kg

Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)	Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)
15. Februar 1912.	24.62 g	21.94 g	19. Februar 1912.	18.78 g	21.89 g
16. „ „	18.77	23.88	20. „ „	19.65	21.15
17. „ „	25.52	22.11	21. „ „	21.77	22.90
18. „ „	26.65	20.09	Im Mittel	<b>22.25</b>	<b>21.99</b>

Periode XIV. Weizen

Hahn Nr. 22, Lebendgewicht 2.22 Kg

Hahn Nr. 24, Lebendgewicht 2.45 Kg

Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)	Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)
1. März 1912.	14.04 g	12.37 g	5. März 1912.	13.00 g	13.41 g
2. „ „	14.44	12.76	6. „ „	11.22	12.35
3. „ „	12.71	13.61	7. „ „	12.00	13.68
4. „ „	13.20	11.94	Im Mittel	<b>13.03</b>	<b>12.87</b>

Periode XV. Sojabohnenkuchen

Hahn Nr. 22, Lebendgewicht 2.42 Kg

Hahn Nr. 24, Lebendgewicht 2.53 Kg

Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)	Datum	Hahn Nr. 22 Exkrement (lufttrocken)	Hahn Nr. 24 Exkrement (lufttrocken)
13. März 1912.	14.67 g	18.88 g	17. März 1912.	19.63 g	20.96 g
14. „ „	19.82	18.05	18. „ „	19.57	20.95
15. „ „	20.06	22.60	19. „ „	19.31	20.36
16. „ „	19.15	19.03	Im Mittel	<b>18.89</b>	<b>20.12</b>

## Anhang II. II. Versuchsreihe

## Periode I. Gerste

Operierter Hahn Nr. 22, Lebendgewicht 2.15 Kg

Datum	Kot (lufttrocken)	Harn (lufttrocken)	Datum	Kot (lufttrocken)	Harn (lufttrocken)
27. Mai 1912.	9.40 g	3.21 g	31. Mai 1912.	7.75 g	2.81 g
28. „ „	10.18	3.73	1. Juni 1912.	9.25	3.27
29. „ „	8.66	4.27	2. „ „	9.40	4.11
30. „ „	10.48	2.34	Im Mittel	<b>9.30</b>	<b>3.53</b>

## Periode II. Fischguano

Operierter Hahn Nr. 22, Lebendgewicht 2.03 Kg

Datum	Kot (lufttrocken)	Harn (lufttrocken)	Datum	Kot (lufttrocken)	Harn (lufttrocken)
18. Juni 1912.	10.66 g	5.60 g	22. Juni 1912.	8.30 g	5.03 g
19. „ „	9.10	5.91	23. „ „	9.61	4.21
20. „ „	11.16	5.27	24. „ „	8.77	5.92
21. „ „	9.66	5.06	Im Mittel	<b>9.60</b>	<b>5.29</b>

## Periode III. Weizen

Operierter Hahn Nr. 22, Lebendgewicht 1.96 Kg

Datum	Kot (lufttrocken)	Harn (lufttrocken)	Datum	Kot (lufttrocken)	Harn (lufttrocken)
15. Juli 1912.	6.21 g	2.11 g	19. Juli 1912.	6.33 g	1.56 g
16. „ „	8.17	2.09	20. „ „	5.49	2.11
17. „ „	6.47	2.23	21. „ „	7.81	2.92
18. „ „	4.55	1.87	Im Mittel	<b>6.43</b>	<b>2.13</b>

Periode IV. Weizenkleie

Operierter Hahn Nr. 22, Lebendgewicht 1.57 Kg

Datum	Kot (lufttrocken)	Harn (lufttrocken)	Datum	Kot (lufttrocken)	Harn (lufttrocken)
24. August 1912.	13.38 g	5.84 g	28. August 1912.	10.04 g	6.04 g
25. " "	12.50	7.34	29. " "	12.80	6.34
26. " "	12.02	5.64	30. " "	10.74	6.36
27. " "	11.28	7.36	Im Mittel	<b>11.82</b>	<b>6.42</b>

Periode V. Gerste.

Operierter Hahn Nr. 22, Lebendgewicht 1.82 Kg

Datum	Kot (lufttrocken)	Harn (lufttrocken)	Datum	Kot (lufttrocken)	Harn (lufttrocken)
9. September 1912.	10.52 g	2.73 g	13. September 1912.	7.28 g	3.22 g
10. " "	7.46	2.55	14. " "	10.98	2.86
11. " "	10.96	2.86	15. " "	9.95	3.38
12. " "	10.06	2.87	Im Mittel	<b>9.60</b>	<b>2.93</b>

Periode VI. Fischguano

Operierter Hahn Nr. 22, Lebendgewicht 1.78 Kg

Datum	Kot (lufttrocken)	Harn (lufttrocken)	Datum	Kot (lufttrocken)	Harn (lufttrocken)
5. Oktober 1912.	10.34 g	8.42 g	9. Oktober 1912.	10.03 g	6.61 g
6. " "	9.98	6.26	10. " "	10.20	8.91
7. " "	10.18	6.48	11. " "	10.89	6.12
8. " "	10.11	6.68	Im Mittel	<b>10.25</b>	<b>7.07</b>

## Periode VII. Futtergemisch

Operierter Hahn Nr. 22, Lebendgewicht 1.98 Kg

Datum	Kot (lufttrocken)	Harn (lufttrocken)	Datum	Kot (lufttrocken)	Harn (lufttrocken)
29. Oktober 1912.	14.31 g	7.39 g	2. November 1912.	11.87 g	7.78 g
30. " "	14.66	9.55	3. " "	13.75	8.12
31. " "	16.07	9.36	4. " "	12.35	9.25
1. November 1912.	10.66	9.00	Im Mittel	<b>13.33</b>	<b>8.64</b>

## Periode VIII. Futtergemisch

Operierter Hahn Nr. 22, Lebendgewicht 2.12 Kg

Datum	Kot (lufttrocken)	Harn (lufttrocken)	Datum	Kot (lufttrocken)	Harn (lufttrocken)
11. November 1912.	8.90 g	5.04 g	15. November 1912.	7.43 g	7.33 g
12. " "	7.76	6.11	16. " "	7.24	7.84
13. " "	9.58	6.86	17. " "	8.20	6.60
14. " "	6.91	6.23	Im Mittel	<b>8.00</b>	<b>6.57</b>

## Periode IX. Futtergemisch

Operierter Hahn Nr. 22, Lebendgewicht 2.23 Kg

Datum	Kot (lufttrocken)	Harn (lufttrocken)	Datum	Kot (lufttrocken)	Harn (lufttrocken)
6. Dezember 1912.	11.66 g	8.27 g	10. Dezember 1912.	9.99 g	9.55 g
7. " "	10.92	8.57	11. " "	13.69	10.42
8. " "	12.40	8.02	12. " "	12.84	10.22
9. " "	13.57	9.99	Im Mittel	<b>12.15</b>	<b>9.30</b>

Periode X. Weizenkleie

Operierter Hahn Nr. 22, Lebendgewicht 1.86 Kg

Datum	Kot (lufttrocken)	Harn (lufttrocken)	Datum	Kot (lufttrocken)	Harn (lufttrocken)
24. Januar 1913.	9.26 g	6.16 g	28. Januar 1913.	13.16 g	4.35 g
25. " "	14.11	4.76	29. " "	10.48	4.09
26. " "	12.58	3.72	30. " "	13.20	3.68
27. " "	14.52	3.76	Im Mittel	<b>12.48</b>	<b>4.35</b>

Periode XI. Weizen

Operierter Hahn Nr. 22, Lebendgewicht 1.46 Kg

Datum	Kot (lufttrocken)	Harn (lufttrocken)	Datum	Kot (lufttrocken)	Harn (lufttrocken)
19. Februar 1913.	6.28 g	2.33 g	23. Februar 1913.	6.02 g	2.10 g
20. " "	5.32	2.86	24. " "	6.80	2.75
21. " "	6.02	2.89	25. " "	6.13	2.74
22. " "	5.40	2.91	Im Mittel	<b>6.00</b>	<b>2.65</b>

Periode XII. Kartoffelpülpe

Operierter Hahn Nr. 22, Lebendgewicht 1.53 Kg

Datum	Kot (lufttrocken)	Harn (lufttrocken)	Datum	Kot (lufttrocken)	Harn (lufttrocken)
28. März 1913.	10.28 g	1.54 g	1. April 1913.	10.45 g	1.50 g
29. " "	9.50	1.52	2. " "	8.12	1.48
30. " "	8.78	1.30	3. " "	10.01	1.43
31. " "	7.28	1.47	Im Mittel	<b>9.20</b>	<b>1.46</b>

## Periode XIII. Weizenkleie

Operierter Hahn Nr. 22, Lebendgewicht 2.15 Kg

Datum	Kot (lufttrocken)	Harn (lufttrocken)	Datum	Kot (lufttrocken)	Harn (lufttrocken)
10. Juni 1913.	13.88 g	4.10 g	14. Juni 1913.	15.70 g	3.86 g
11. " "	13.49	4.49	15. " "	15.95	2.64
12. " "	15.17	4.47	16. " "	14.11	5.15
13. " "	12.86	3.83	Im Mittel	<b>14.45</b>	<b>4.08</b>

## Periode XIV. Weizen

Operierter Hahn Nr. 22, Lebendgewicht 1.93 Kg

Datum	Kot (lufttrocken)	Harn (lufttrocken)	Datum	Kot (lufttrocken)	Harn (lufttrocken)
23. Juni 1913.	6.05 g	4.15 g	27. Juni 1913.	6.60 g	2.85 g
24. " "	6.63	2.23	28. " "	6.95	2.57
25. " "	7.60	2.62	29. " "	6.19	4.00
26. " "	6.54	2.68	Im Mittel	<b>6.65</b>	<b>3.01</b>

## Periode XV. Reisfuttermehl

Operierter Hahn Nr. 22, Lebendgewicht 1.78 Kg

Datum	Kot (lufttrocken)	Harn (lufttrocken)	Datum	Kot (lufttrocken)	Harn (lufttrocken)
22. Juli 1913.	13.21 g	3.70 g	26. Juli 1913.	13.50 g	3.47 g
23. " "	13.52	3.55	27. " "	13.18	3.38
24. " "	13.47	3.57	28. " "	13.10	3.60
25. " "	13.28	3.83	Im Mittel	<b>13.32</b>	<b>3.51</b>

Periode XVI. Ungeschälter Reis

Operierter Hahn Nr. 22, Lebendgewicht 1,97 Kg

Datum	Kot (lufttrocken)	Harn (lufttrocken)	Datum	Kot (lufttrocken)	Harn (lufttrocken)
19. Oktober 1913.	11.29 g	2.63 g	23. Oktober 1913.	10.54 g	2.61 g
20. " "	11.03	2.63	24. " "	11.96	2.61
21. " "	9.46	3.03	25. " "	10.63	2.42
22. " "	9.65	3.11	Im Mittel	<b>10.65</b>	<b>2.72</b>

Periode XVII. Geschälter Reis, Kleeheu

Operierter Hahn Nr. 22, Lebendgewicht 1,78 Kg

Datum	Kot (lufttrocken)	Harn (lufttrocken)	Datum	Kot (lufttrocken)	Harn (lufttrocken)
30. Oktober 1913.	10.19 g	3.49 g	3. November 1913	11.59 g	3.24 g
31. " "	9.72	2.88	4. " "	10.22	2.87
1. November 1913.	10.65	3.19	7. " "	11.80	4.85
2. " "	11.16	3.33	Im Mittel	<b>70.76</b>	<b>3.41</b>

Periode XVIII. Sojabohnenkuchen

Operierter Hahn Nr. 22, Lebendgewicht 1,80 Kg

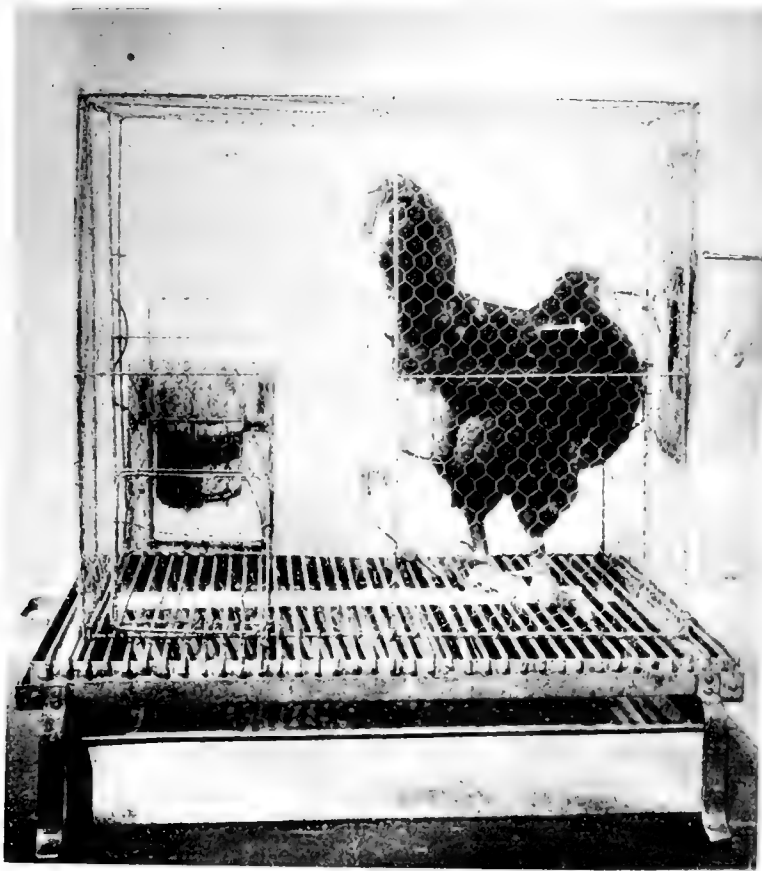
Datum	Kot (lufttrocken)	Harn (lufttrocken)	Datum	Kot (lufttrocken)	Harn (lufttrocken)
17. November 1913.	6.45 g	6.25 g	21. November 1913	6.73 g	6.04 g
18. " "	5.75	4.25	22. " "	5.62	5.33
19. " "	6.24	6.60	23. " "	6.43	6.59
20. " "	6.12	5.03	Im Mittel	<b>6.19</b>	<b>5.78</b>

## Periode XIX. Weizen

Operierter Hahn Nr. 22, Lebendgewicht 2.01 Kg

Datum	Kot (lufttrocken)	Harn (lufttrocken)	Datum	Kot (lufttrocken)	Harn (lufttrocken)
20. Oktober 1913.	6.90 g	3.35 g	24. Oktober 1913.	6.87 g	3.46 g
21. " "	6.40	3.50	25. " "	6.06	3.51
22. " "	6.22	3.31	26. " "	6.87	3.07
23. " "	6.84	3.31	Im Mittel	<b>6.59</b>	<b>3.32</b>











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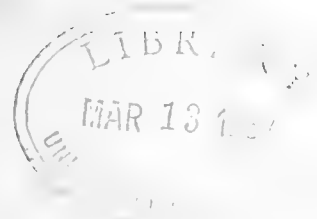
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NISHIGAHARA, TOKYO  
NOVEMBER, 1928



# The Encyrtinae of Japan

By

TEI ISHII

*Assistant Entomologist, Imperial Agricultural Experiment Station*

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With 57 Figures in Text

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In economic importance the Encyrtid-flies are the most beneficial insects which in many ways help to control Coccids, Psyllids, Aphids and many other insects injurious to farm and fruit plants. Up to the present our knowledge concerning their fauna of Japan has been augmented by L. O. HOWARD, W. H. ASHMEAD, P. H. TIMBERLAKE, H. S. SMITH, H. COMPERE and myself, the species already recorded amounting to 32 in all. Of this number 29 are those that have been described as new, while the rest are those previously known from other parts of the world.

My own study has revealed 41 more species unrecorded before from Japan. Of these 34 seem to be new to science. Thus there are in all 73 species to the Encyrtid-fauna of Japan as at present known. These are referable to 3 tribes and 37 genera. Now in this paper I propose to describe all the aforesaid 73 species, most of which were obtained from rearing Coccids and some other insects and by sweeping in the field chiefly in the vicinity of Nagasaki. These are as follows:

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Taking into consideration the species here dealt with, our Encyrtid-fauna has, on the whole, a close affinity to that of the Palaearctic and Oriental regions as well as to that of the Nearctic region to a certain degree. However, a large number of peculiar genera are found in the fauna, such as *Cerapterocroides*, *Metacerapterocerus*, *Parausemion*, *Flesio-microterys* gen. nov., *Heteroleptomastix* gen. nov., *Cynipencyrtus* gen. nov., *Aphidencyrtoides* gen. nov., *Clausenia* and *Astymachus*. It is of some interest to know that *Anicetus annulatus*, *Anagyrus antoninae*, *Anabrolepis extranea*, *Encyrtus barbatus* and *Comperiella bifasciata* occur both in Japan and Hawaii which are very remote from each other. These have probably been accidentally introduced from the one into the other.

The classification of the Encyrtinae is a very difficult task owing to the fact that the genera are highly specialized in various directions so as to be nearly incapable of determining their natural relationships. Setting aside the classification of that subfamily proposed by ASHMEAD, MERCET divides it into 12 groups. However, the writer is inclined to think it better to divide the subfamily into 3 tribes—Ectromini, Encyrtini and Mirini—, following ASHMEAD and TIMBERLAKE.

As regards the male genitalia of some species available, examination proves that the male genitalia may serve as one of the most important taxonomical characters. In the members of the same groups the clasper is beset with the same number of hooks, for example: 3 in *Homalotylus* and *Isodromus*, 2 in *Aphycus* and *Blastothrix*, and only one in *Microterys*, *Syrphophagus*, *Aphidencyrtoides*, *Cheiloneurus*, *Anicetus*, *Phaenodiscus* and *Parausemion*. If a more thorough study is made of the male genitalia of as many species as possible, it is probable that the tribes can be divided into many subtribes by the aid of this character together with other important characters which may be found. Unfortunately the males in the Encyrtinae are usually much fewer in numbers as compared to the females.

Before proceeding further, the writer takes the opportunity to express his sincere thanks to Professor HIROTARO ANDO, Dr. INOKICHI KUWANA and Professor TOKIO KABURAKI for valuable help and advice rendered him during the course of the present work. My thanks are also due to

Messrs. S. KARIYA, P. H. TIMBERLAKE, C. P. CLAUSEN, F. SILVESTRI, R. G. MERCET, L. O. HOWARD, H. S. SMITH, H. COMPERE and L. MASI for assistance generously given.

Tribe I. **Ectromini** ASHMEAD

Encyrtinae with slenderly elongated body; marginal vein proportionately longer, stigmal vein moderately long; labrum inconspicuous; mandibles rather smaller, narrower, and always bidentate at apex. This last character, together with the prominent hypopygium in the female, may be regarded as being of sufficient magnitude to distinguish the species falling in this group.

**Key to the genera**

**Female**

- 1. Scape cylindrical ... .. 2  
 Scape much dilated below ... .. *Anagyrus* HOWARD
- 2. Antennae filiform, as long as or much longer than the body ... .. 3  
 Antennae clavate or subclavate, much shorter than the body ... .. 4
- 3. Fore wings with leopard-like spots ... .. *Callipteroma* MOTSCHULSKY  
 Fore wings faintly infusate ... .. *Leptomastix* FÖRSTER
- 4. Antennae clavate; club considerably wider than the last funicle joint and obliquely truncated below; marginal vein long; maxillary palpi 4-jointed; labial palpi 3-jointed.  
*Clausenia* ISHII
 Antennae subclavate; club almost as wide as the last funicle joint and not obliquely truncated below; marginal vein short; maxillary palpi 3-jointed; labial palpi 2-jointed ... .. *Doliphoceras* MERCET

**Male**

- 1. Scape cylindrical ... .. 2  
 Scape much dilated below ... .. *Anagyrus* HOWARD
- 2. Antennae much longer than the body ... .. 3  
 Antennae much shorter than the body ... .. 4
- 3. Fore wings with leopard-like spots ... .. *Callipteroma* MOTSCHULSKY  
 Fore wings faintly infusate ... .. *Leptomastix* FÖRSTER
- 4. Funicle cylindrical and slender; last funicle joint and club with sensory fringes; maxillary palpi 3-jointed; labial palpi 2-jointed ... .. *Doliphoceras* MERCET  
 Funicle not cylindrical, considerably dilated at the middle, stout, the joints connected together at the lower parts; last funicle joint and club without sensory fringes; maxillary palpi 4-jointed; labial palpi 3-jointed ... .. *Clausenia* ISHII

### Anagyrus HOWARD

*Anagyrus* HOWARD, Proc. U.S. Nat. Mus., XVIII (1896), p. 638; ASHMEAD, Proc. U.S. Nat. Mus., XXII (1900), p. 354; SCHMIEDERKNECHT, Gen. Ins., XCVII (1909), p. 201; MURLET, Fauna Ibérica, Encirt., 1921, p. 132.

#### Key to the species

##### Female

- 1. Body slender; abdomen much longer than the head and thorax combined; last funicle joint and club white ... .. *antoniae* TIMBERLAKE  
 Body rather stout; abdomen almost as long as the head and thorax combined or shorter ... .. 2
- 2. Antennae with whitish joints ... .. 3  
 Antennae black in general ... .. *subagricornis* sp. nov.
- 3. Funicle with one or five joints, whitish ... .. 4  
 Funicle dark brown, club whitish ... .. 5
- 4. Last funicle joint and club whitish ... .. *filosus* sp. nov.  
 Last five funicle joints and club whitish ... .. 6
- 5. Pro- and meso-notum brown with a slight bluish reflection... .. *alboclavatus* sp. nov.  
 Pro- and meso-notum orange yellow ... .. *flavus* sp. nov.
- 6. Ocelli in an obtuse-angled triangle; mesonotum dark brown ... .. *subalbipes* sp. nov.  
 Ocelli in an equi-lateral triangle; mesonotum brownish, orange yellow... .. *sarvadai* sp. nov.

##### Male

- 1. Head and body black in general; scape twice as long as wide.  
*antoniae* TIMBERLAKE
- 2. Head yellowish except the frontovertex; mesopleurae yellowish white; scape thrice as long as wide ... .. *flavus* sp. nov.

### Anagyrus antoniae TIMBERLAKE

(Fig. 1.)

*Anagyrus antoniae* TIMBERLAKE, Proc. Haw. Entom. Soc., IV (1920), No. 2, p. 409.

This species appears in the vicinity of Nagasaki, extending over some months from April to October. It was bred from *Antonina craxi* CKILL. on the bamboo. Male genitalia (Fig. 1) rather slender, without lateral process; clasper with three short spines on the tip.

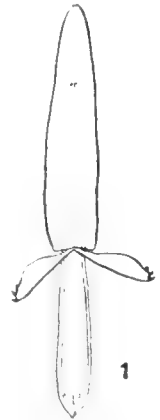


Fig. 1.  
*Anagyrus antoniae*  
TIMB., genitalia  
of male.



**Anagyrus alboclavatus** sp. nov.

Female—Head wider than long (31 : 28); frontovertex at the anterior ocellus as wide as one half the width of the head; ocelli in an obtuse-angled triangle, the posterior pair separated from the eye margins by a space a little more than their diameter, and from the occipital margin by one half their diameter; scrobes rather shallow; mandibles bidentate. Antennae 0.95 mm. in length; scape much dilated below, a little more than twice as long as wide; pedicle twice as long as wide at apex, a little longer than the first funicle joint; funicle joints subequal in length, slightly widening distad, and the first joint slightly longer; club considerably wider than the last funicle joint, and almost as long as the last three funicle joints combined. Axillae separated; scutellum a little longer than the meso-scutum, and as wide as long. Abdomen a little shorter than the head and thorax combined. Fore wings 1.43 mm. in length and 0.6 mm. in width; ciliation uniform; hairless oblique line twice interrupted; submarginal vein with about 17 bristles; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 33 : 3 : 7 : 3.

Head orange yellow in general, paler near the lower part of the face and cheeks, and brownish around the ocelli. Scape black with a whitish band at the base and near the tip; pedicle dark brown with the tip paler; funicle joints dark brown, paler towards the apical joint; club whitish. Mandibles pale yellow with the tip brown. Pro- and meso-notum brown with a slight bluish reflection; prepecti, tegulae and mesopleurae pale yellow; metanotum, propodeon, metapleurae and abdomen brown. Wings hyaline, the veins pale brown.

Head, pro- and meso-notum, metapleurae and abdomen with sparse numbers of whitish hairs. Face and cheeks minutely, scaly reticulate; frontovertex, pro- and meso-notum minutely, raised reticulate; mesopleurae longitudinally striated; abdomen rather coarsely reticulate.

Length of body, 1.5 mm.; width of body, 0.45 mm.

Male—Unknown.

Type in the author's collection.

A female was reared from *Pseudococcus* sp. found on *Ficus erecta* near Nagasaki in April, 1926.

**Anagyrus flavus** sp. nov.

Female—Head as wide as long; frontovertex at the anterior ocellus as wide as three-sevenths the width of the head; ocelli in an obtuse-angled triangle, the posterior pair separated from the eye margins and the occipital margin by a space a little more than twice their diameter; scrobes rather shallow; mandibles bidentate. Antennae 1 mm. in length; scape much dilated below, thrice as long as wide; pedicel twice as long as wide at apex, and as long as the first funicle joint; funicle joints subequal in length, slightly widening distad; first funicle joint thrice as long as wide, and a little longer than the other funicle joints; club a little wider than the last funicle joint, and a little shorter than the last three funicle joints combined. Axillae slightly separated; scutellum a little longer than the mesoscutum, and as long as wide; abdomen a little shorter than the thorax. Fore wings 1.58 mm. long by 0.65 mm. wide, uniformly ciliated except the hairless oblique line; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 37:4:7:5; submarginal vein with about 19 bristles. Middle tibiae with about 8 spines on the tip.

Head yellow, paler towards the end of the mouth; mandibles pale yellow with the tip brown. Antennae quite similar in coloration to those of *A. alboclavatus*. Pro- and meso-notum orange yellow; prepecti, mesopleurae, tegulae, metanotum, metapleurae, propodeon and all the legs pale yellowish red; abdomen pale brown. Wings hyaline, the veins pale brown.

Eyes sparsely pubescent; head, pro- and meso-notum and abdomen with whitish hairs in sparse numbers; scutellum with a pair of brown hairs near the tip. Sculpture similar to that of *A. alboclavatus*.

Length of body, 1.5 mm.; width of thorax, 0.53 mm.

Male—Head wider than deep (31:26); frontovertex at the anterior ocellus as wide as a little more than one half the width of the head; the posterior pair of ocelli separated from the eye margins by a space a little

more than their diameter, and from the occipital margins by that a little less. Mandibles bidentate at apex. Antennae 1 mm. in length; scape considerably dilated below, about thrice as long as wide; pedicle as long as wide at apex; funicle joints with sparse numbers of long hairs, much longer than wide, subequal in length and width except the first joint which is a little longer and about four times as long as wide; club almost as long as the last two funicle joints combined; fore wings 1.28 mm. long by 0.57 mm. wide, uniformly ciliated except the hairless oblique line; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 30:3:6:2; submarginal vein with about 14 bristles; middle tibiae with about 5 spines on the tip.

Head yellow, vertex black except a narrow yellow stripe near the eye margins; occiput brown; mandibles pale yellow with the tip brown. Scape whitish below, brown above; pedicle brown; funicle joints brown, paler towards the apical joint; club whitish yellow. Wings hyaline, the veins pale brown. Legs whitish yellow.

Head, pro- and meso-notum, metapleurae and abdomen with white hairs in sparse numbers. Sculpture similar to that of the female.

Length of body, 1.28 mm.; width of thorax, 0.45 mm.

Types in the author's collection.

Reared from *Pulvinaria* sp. found on *Mallotus japonicus* near Nagasaki in June, 1926.

### **Anagyrus pilosus** sp. nov.

Female—Head a little wider than long (34:32); frontovertex at the anterior ocellus as wide as one-third the width of the head; ocelli in an acute-angled triangle, the posterior pair separated from the eye margins and occipital margin by a space equal to their diameter; scrobes rather shallow, not meeting above; mandibles bidentate at tip. Antennae about 1.17 mm. in length; scape much dilated below, twice as long as wide; pedicle twice as long as wide at apex, a little shorter than the first funicle joint; funicle joints shortening and slightly widening distad, the first joint thrice as long as wide, and the last joint considerably longer than wide;

club a little wider than the last funicle joint, and a little shorter than the last three funicle joints combined. Fore wings 1.29 mm. long by 0.48 mm. wide, uniformly ciliated except the hairless oblique line; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 33:7:5:1; submarginal vein with about 20 bristles. Axillae slightly separated; scutellum as long as wide and a little longer than the mesoscutum; abdomen a little longer than the head and thorax combined.

Eyes almost bare; head, pro- and meso-notum, metapleurae and abdomen with silvery hairs thickly crowded; scutellum with three pairs of black hairs near the tip. Head, pro- and meso-notum, mesopleurae and abdomen minutely, raised reticulate.

Head, pronotum, mesoscutum black; axillae, scutellum and mesopleurae dark yellowish red, and the central part of the scutellum brown; tegulae pale yellowish red; metanotum, propodeon and abdomen dark brown. Wings hyaline, the veins pale brown. Legs pale yellowish red, the middle legs rather whitish.

Length of body, 1.6 mm.; width of thorax, 0.525 mm.

Male—Unknown.

Type in the author's collection.

This new species is represented by only one specimen collected by sweeping near Nagasaki in October, 1925.

### **Anagyrus sawadai** sp. nov.

Female—Head a little wider than deep (32:30); frontovertex at the anterior ocellus as wide as one-third the width of the head; ocelli in an equi-lateral triangle, the posterior pair separated from the eye margins and the occipital margin by a space a little less than their diameter; scrobes moderately deep; mandibles bidentate at tip, the lower tooth more or less larger. Antennae 1 mm. in length; scape much dilated below; pedicel thrice as long as wide at apex, and a little longer than the first funicle joint; funicle joints subequal in length and width, the last two joints slightly shorter and wider; club elongate-oval, much wider than the last

funicle joint, and considerably longer than the last two funicle joints combined. Fore wings 1.13 mm. long by 0.5 mm. wide, uniformly ciliated except the hairless oblique line; submarginal, marginal, stigmal and post-marginal veins approximately in the ratio of 30:3:5:1; submarginal vein with about 20 bristles. Abdomen almost as long as the head and thorax combined; ovipositor hidden. Hind tibiae with about 7 spines on the tip.

Head, pro- and meso-notum and mesopleurae minutely reticulate. Eyes thickly pubescent; head, pro- and meso-notum, mesopleurae and abdomen with thick whitish hairs.

Head orange yellow in general and brownish near the posterior part of the cheeks; pro- and meso-notum orange yellow with a touch of brown; tegulae and prepecti whitish; mesopleurae orange yellow; metapleurae brown; metanotum, propodeon and abdomen brownish black. Scape black, white on the upper margin, with a white transverse band near the base and tip; pedicel black, the apical half whitish; first funicle joint dark brown, the other joints and club white. Wings hyaline, the veins pale brown. Fore legs pale brown; middle and hind legs pale yellow.

Length of body, 1.23 mm.; width of thorax, 0.45 mm.

Male—Unknown.

Types in the author's collection.

This new species is based upon two females reared from *Eriococcus* sp. found on *Cryptomeria japonica* at Isahaya near Nagasaki in July, 1924.

**Anagyrus subnigricornis** sp. nov.

(Fig. 2.)

Female—Head slightly wider than deep (36:34); frontovertex at the anterior ocellus as wide as a little more than one half the width of the head; ocelli in a rather equi-lateral triangle, the posterior pair separated from the eye margins by about their diameter and from the occipital margin by a little more; mandibles bidentate. Antennae (Fig. 2) 1.29 mm.



Fig. 2.  
*Anagyrus subnigri-*  
*cornis* sp. nov.,  
antenna of female.

in length; scape much dilated below, a little more than twice as long as wide; pedicle long, a little less than thrice as long as wide at apex, and as long as the first funicle joint; funicle joints subequal in width, gradually lengthening distad, the first funicle joint four times as long as wide, and the last as long as wide; club a little wider than the last funicle joint, and considerably shorter than the last three funicle joints combined. Fore wings 1.5 mm. in length and 0.62 mm. in width, and uniformly ciliated in apical two-thirds; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 38:7:6:5; submarginal vein with about 28 bristles. Abdomen considerably longer than the thorax; ovipositor hidden; middle tibiae with about 9 spines on the tip.

Head, pro- and meso-notum and mesopleurae minutely reticulate; abdomen coarsely reticulate. Eyes sparsely pubescent; cheeks, pro- and meso-notum, metapleurae and abdomen with whitish hairs; scutellum with two pairs of black hairs near the tip.

Body brownish orange yellow in general; scape black with a white transverse band near the base and tip, and flagellum brownish black; posterior half of prepecti and basal third of tegulae whitish, the anterior half of the former and apical two-thirds of the latter pale brown; metapleurae and abdomen brown. Wings hyaline, the veins brown. Legs pale reddish brown with a touch of yellow; upper margin of all the femora and tibiae brownish black.

Length of body, 1.65 mm.; width of thorax, 0.57 mm.

Male—Unknown.

Type in the author's collection.

The present species is represented by a single specimen collected by sweeping near Nagasaki in July, 1924. It is closely allied to *A. nigricornis* TIMBERLAKE recorded from Hawaii.

### **Anagyrus subalbipes** sp. nov.

(Fig. 3.)

Female—Head a little wider than deep (38:35); frontovertex at the anterior ocellus as wide as one-third the width of the head; ocelli in an

obtuse-angled triangle, the posterior pair separated from the eye margins and the occipital margin by a space a little less than their diameter; mandibles bidentate, the lower tooth smaller. Antennae (Fig. 3) 1.35 mm. in length; scape much dilated below, a little more than twice as long as wide; pedicle long, about thrice as long as wide at apex; funicle joints longer than wide, slightly widening distad, the first joint a little more than twice as long as wide, and considerably shorter than the pedicle; club a little wider than the last funicle joint, and a little shorter than the last three funicle joints combined. Fore wings 1.5 mm. in length and 0.63 mm. in width, and uniformly ciliated except the hairless oblique line; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 38 : 4 : 7 : 2; submarginal vein with about 28 bristles. Middle tibiae with about 12 spines on the tip.

Head, pro- and meso-notum, mesopleurae and abdomen very minutely reticulate. Face, pro- and meso-notum, metapleurae and abdomen with thick whitish hairs.

Head, pro- and meso-notum and mesopleurae brownish orange yellow, brownish black at between the toruli, occiput and posterior part of cheeks; mandibles yellowish, the tip dark brown. Scape black with a transverse whitish band near the base and tip; pedicle black, the apical half whitish; first funicle joint black, the remainder of the funicle and club white. Metapleurae, propodeon and abdomen brownish black, the sides of the propodeon orange yellow; tegulae whitish except the apical half which is pale brown. Wings hyaline, the veins pale brown. Legs whitish; all the tarsi yellowish; the apex of all the legs brownish; the outer margin of the fore coxae and femora, and of the hind tibiae pale brown.

Length of body, 2 mm.; width of thorax, 0.6 mm.

Male—Unknown.

Type in the author's collection.

This new species is based upon a single female reared from *Pseudo-*

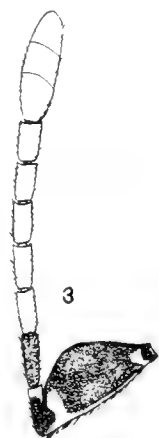


Fig. 3.  
*Angyrus subalbipes*  
sp. nov., antenna  
of female.

*coccus* sp. found on the citrus tree near Nagasaki in July, 1922. It is closely allied to *A. greeni* HOWARD, but differs from it in the following points: 1) The pedicle of the antennae is a little longer than the first funicle joint; 2) the ocelli are arranged in an obtuse-angled triangle; 3) the mesopleurae present no striation.

### *Doliphoceras* MERCET

*Doliphoceras* MERCET, Fauna Ibérica, Encirt., 1921, p. 91.

#### *Doliphoceras niger* sp. nov.

(Figs. 4-6.)

Female—Head wider than long (33:27); frontovertex broad, at the anterior ocellus as wide as one half the width of the head; ocelli in an obtuse-angled triangle, the posterior pair separated from the eye margins by a space twice their diameter and from the occipital margin by a little more than their diameter; scrobes very shallow, not meeting above; mandibles bidentate; maxillary palpi three-jointed and labial palpi two-

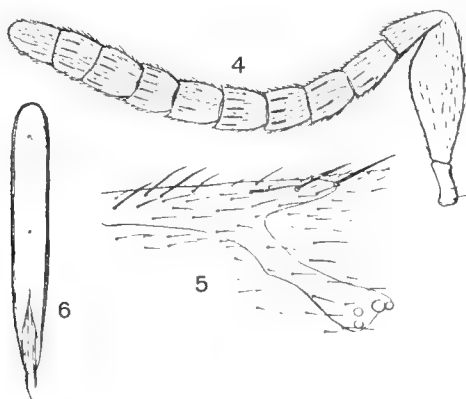


Fig. 4. *Doliphoceras niger* sp. nov., antenna of female.

Fig. 5. Ditto, veins of fore wing of female.

Fig. 6. Ditto, genitalia of male.

jointed. Antennae (Fig. 4) 0.95 mm. in length; scape considerably dilated below, and almost thrice as long as wide; pedicle twice as long as wide at apex, and a little longer than the first funicle joint; funicle joints



subequal in length except the first joint which is a little longer, and slightly widening distad; club a little wider than the last funicle joint, and a little shorter than the last three funicle joints combined. Axillae meeting; scutellum as long as wide and as long as mesoscutum; propodeon very short medianly. Abdomen considerably longer than the head and thorax combined; ovipositor as long as one-sixth the length of the abdomen, and the sheaths very broad. Fore wings 1.38 mm. in length and 0.5 mm. in width, uniformly ciliated except the hairless oblique line; submarginal, marginal, stigmal and postmarginal veins (Fig. 5) approximately in the ratio of 35 : 5 : 5 : 2. Middle tibiae with about 6 spines on the tip. Head, pro- and meso-notum and abdomen minutely, scaly reticulate; mesopleurae longitudinally, scaly reticulate.

Black in general; eyes pubescent; antennae black with rather thick, short brownish hairs; tegulae brown. Wings subhyaline or faintly clouded, the veins pale brown. Legs yellowish except the middle and hind coxae which are brownish; ovipositor brown, paler towards the base. Pro- and meso-notum, metapleurae and abdomen with whitish hairs in scattered distribution.

Length of body, 1.65 mm.; width of thorax, 0.45 mm.

Male—Sculpture and coloration similar to those of the female. Antennae 0.87 mm. in length; scape cylindrical; pedicle twice as long as wide at apex, and shorter than the first funicle joint; funicle joints longer than wide, subequal in length and width, the first joint slightly longer, and thrice as long as wide; club entire, as long as the last two funicle joints combined; funicle and club with sparse long hairs; last funicle joint and club with sensory fringes. Fore wings 1.05 mm. long by 0.39 mm. wide; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 25 : 3 : 3 : 2; submarginal vein with about 19 bristles. Middle tibiae with about 4 spines on the tip.

Male genitalia (Fig. 6) slender without lateral process and clasper.

Length of body, 1.35 mm.; width of thorax, 0.35 mm.

Types in the author's collection.

This new species is represented by two specimens, a female and a male,

collected by sweeping at Mt. Ôyama, Kanagawa-ken in June, 1923. It is allied to *D. integralis* (MERCET) of Spain, but may be distinguished from it by the ovipositor which is extruded.

***Doliphoceras rufoscutata* sp. nov.**

Female—Head wider than long (30:25); frontovertex at the anterior ocellus as wide as one half the width of the head; ocelli in an obtuse-angled triangle, the posterior pair separated from the eye margins by a space twice their diameter and from the occipital margin by about their own; scrobes indistinct; mandibles bidentate. Antennae 0.86 mm. in length; scape considerably dilated below, a little longer than thrice as long as wide; pedicle twice as long as wide at apex, and a little longer than the first funicle joint; funicle joints longer than wide, subequal in length, the first joint a little longer, thrice as long as wide, club three-jointed, a little wider than the last funicle joint, and as long as the last three funicle joints combined. Fore wings 1.28 mm. in length and 0.5 mm. in width; ciliation uniform except the hairless oblique line; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 32:4:5:2; submarginal veins with about 18 bristles. Abdomen longer than the thorax and head combined; ovipositor about one-sixth the length of the abdomen.

Head, pro- and meso-notum, mesopleurae and abdomen very minutely, scaly reticulate. Eyes pubescent; head, pro- and meso-notum, metapleurae and abdomen with grey hairs in sparse numbers.

Head, pronotum and basal half of abdomen black; axillae, scutellum and apical half of abdomen dark brown, the remaining parts of the body reddish yellow. Legs pale red-yellow. Antennae black; the basal half of the scape reddish yellow, the tip of the pedicle paler.

Length of body, 1.73 mm.; width of thorax, 0.38 mm.

Male—Unknown.

Types in the author's collection.

This new species is based upon two female specimens collected by sweeping near Nagasaki in October, 1923.

***Leptomastix* FÖRSTER**

*Leptomastix* FÖRSTER, Hym. Stud., II (1856), p. 34; MAYR, Verh. k. k. zool.-bot. Ges. Wien, XXV (1875), p. 729; ASHMEAD, Proc. U. S. Nat. Mus., XXII (1900), p. 353; SCHMIEDERNECHT, Gen. Ins., XCVII (1909), p. 201; MERCET, Fauna Ibérica, Encirt., 1921, p. 119.

*Stenoterys* THOMSON, Hym. Scand. IV (1875), p. 128.

***Leptomastix citri* sp. nov.**

(Fig. 7.)

Female—Head wider than long (37 : 29); frontovertex at the anterior ocellus as wide as a little less than one half the width of the head; ocelli in an obtuse-angled triangle, the posterior pair as equally separated from each other as from the eye margins, separated from the eye margins by a space twice their diameter and from the occipital margin by a little less than their diameter; face with a longitudinal keel between the toruli, on each side of which are found four strong bristles arranged longitudinally; scrobes shallow; mandibles bidentate, the upper tooth more or less larger. Antennae 1.5 mm. in length; scape slender, cylindrical and about as long as the first two funicle joints combined; pedicle twice as long as wide at apex, almost one half as long as the first funicle joint; funicle joints longer than wide, shortening and widening distad, the first joint four times as long as wide, and the last joint two-thirds as wide as long; club as long as the last two funicle joints combined. Axillae meeting; propodeon with two parallel median calinae; abdomen a little longer than the thorax. Fore wings 1.58 mm. long by 0.5 mm. wide, and uniformly ciliated except the hairless oblique line; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 36 : 8 : 6 : 8; submarginal vein with about 19 bristles. Middle tibiae with about 10 spines on the tip.

Head, pro- and meso-notum minutely, scaly reticulate; frontovertex more or less raised reticulate; abdomen feebly reticulate.

Eyes bare; pro- and meso-notum with sparse black hairs, scutellum with two pairs of long black hairs near the tip.

Body yellowish red in general; scape yellowish with the dorsal margin

black; pedicle brown; funicle joints and club black; mandibles yellowish red, with the tip brown. The part behind the eyes, posterior two-thirds of mesopleurae, metanotum, propodeon, metapleurae and abdomen brown. Legs yellowish red, hind tibiae and tarsi brownish. Wings faintly clouded, the veins yellowish brown.

Length of body, 1.59 mm.; width of thorax, 0.56 mm.

Male—Sculpture and coloration similar to those of the female. Antennae 1.8 mm. long; scape slender, about as long as the pedicle and first funicle joint combined; pedicle a little longer than wide at apex; funicle joints subequal in width, gradually shortening distad, the first joint a little more than five times as long as wide, and a little more than thrice as long as the pedicle; club a little shorter than the last two funicle joints combined. Funicle joints and club with sparse numbers of long black hairs.



Fig. 7.  
*Leptomastix citri* sp.  
nov., genitalia of  
male.

Male genitalia (Fig. 7) rather stout, without lateral process; clasper with three large spines.

Length of body, 1.43 mm.; width of thorax, 0.53 mm.

Types in the author's collection.

This new species is reared from *Pseudococcus* sp. found attached to the citrus tree near Nagasaki in some months from April to October, 1923. It is allied to *L. histro* MAYR of Europe, but differs from it in the arrangement of ocelli and the coloration of hairs on the scutellum.

### ***Callipteroma* MOTSCHULSKY**

*Callipteroma* ASHMEAD, Proc. U. S. Nat. Mus., XXII (1900), p. 402; SCHMIEDER-KNECHT, Gen. Ins. XCVII (1909), p. 254; MERCET, Fauna Ibérica, Encirt., 1921, p. 115.

#### ***Callipteroma kiushiensis* sp. nov.**

(Figs. 8 and 9.)

Male—Head wider than deep (38:35); frontovertex at the anterior ocellus as wide as more than one half the width of the head; ocelli in

an equi-lateral triangle, the posterior pair separated from the eye margins by a space about thrice their diameter and from the occipital margin by that a little less than their diameter; scrobes shallow; mandibles bidentate. Antennae (Fig. 8) 2.63 mm. in length; scape long, cylindrical, and about

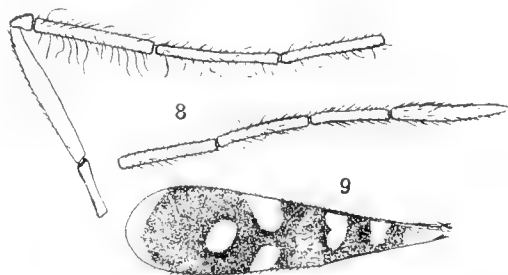


Fig. 8. *Callipt. roma liushiuensis* sp. nov., antenna of male.

Fig. 9. Ditto, fore wing of male.

as long as the pedicel and first funiculus joint combined; pedicel a little longer than wide at apex; funiculus joints very long, cylindrical, and gradually shortening distad; club considerably longer than the last funiculus joint. Fore wings (Fig. 9) 2.1 mm. long by 0.56 mm. wide, and uniformly ciliated except hyaline parts; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 45:12:8:5. Hind wings 1.13 mm. in length and 0.12 mm. in width, and uniformly ciliated.

Face and frontovertex minutely raised reticulate; pro- and meso-notum minutely, scaly reticulate; mesopleurae minutely reticulate; abdomen coarsely reticulate.

Head and thorax entirely dark reddish brown; abdomen black. The lower part of the face with silvery hairs in sparse numbers; metapleurae and basal sides of abdomen with thick silvery hairs. Scape yellowish brown; pedicel brown; funiculus joints and club dark brown, with long black hairs. Fore wings fuscous with seven large hyaline spots; hind wings pale fuscous, much paler towards the tip. Legs yellowish red-brown, the terminal joints of all the tarsi brownish.

Length of body, 1.58 mm.; width of thorax, 0.53 mm.

Female—Unknown.

Type in the author's collection.

This new species is based upon a single specimen collected by sweeping near Nagasaki in August, 1924. Though allied to *C. sexguttata* MORSCH., it differs from it chiefly in coloration.

***Clausenia* ISHII**

*Clausenia* ISHII, Dept. Agr. & Comm. Japan, Imp. Plant Quar. Sta., Bull. 3 (1923), p. 98.

***Clausenia purpurea* ISHII**

*Clausenia purpurea* ISHII, Dept. Agr. & Comm. Japan, Imp. Plant Quar. Sta., Bull. 3 (1923), p. 100.

This species is one of the most important parasites of *Pseudococcus* sp. feeding on the citrus tree in Japan, and was collected near Nagasaki in some months from April to November.

Tribe II. **Encyrtini** ASHMEAD

Encyrtinae with broad and robust body; mandibles larger, broadly truncated at apex and edentate, or bidentate with the lower tooth much smaller; labrum conspicuous; antennae similar in both sexes; marginal veins usually long; marginal cell in the hind wing broadly elongate.

**Key to the genera**

**Female and male**

1. Scutellum with a bunch of hairs at apex; mandibles broadly truncate at apex; anterior margin of fore wing normal ... .. *Encyrtus* LATREILLE
2. Scutellum without a bunch of hairs at apex; mandibles bidentate with the lower tooth much smaller; anterior margin of fore wing deeply excavated at the terminal point of the submarginal vein ... .. *Eugahania* MERCET

***Encyrtus* LATREILLE**

*Encyrtus* THOMSON, Hym. Scand., IV (1875), p. 127; ASHMEAD, Proc. U. S. Nat. Mus., XXII (1900), p. 359.

*Encyrtus* FÖRSTER, Hym. Stud., II (1856), p. 32; SCHMIEDL-KNECHT, Gen. Ins., XCVII (1909), p. 193; MURLET, Fauna Ibérica, Encirt., 1921, p. 557.

*Comys* FÖRSTER, Hym. Stud., II (1856), p. 144; MAYR, Verh. k. k. zool.-bot. Ges. Wien, XXV (1875), p. 740.

***Encyrtus barbatus* TIMBERLAKE**

*Encyrtus barbatus* TIMBERLAKE, Proc. Haw. Entom. Soc., IV (1919), No. 1, p. 209.

Reared from *Coccus hesperidum* L. on the citrus tree, Sept. 25, 1920,

Nagasaki, and from *Pulvinaria camelicola* SIGN. on *Ilex otherea*, June 7, 1923, Ozuki, Kanagawa-ken. This species is known to occur in the Philippines, Java and Hawaii. Hitherto unrecorded from Japan.

***Encyrtus sasakii* sp. nov.**

(Fig. 10.)

Female—Head wider than long (65 : 55); frontovertex at the anterior ocellus as wide as about one half the width of the head; ocelli in an obtuse-angled triangle, the posterior pair separated from the eye margins and the occipital margin by a space a little less than their diameter; scrobes shallow, round; the part between the toruli roundly elevated to a slight degree; clypeal edge with four bristles; mandibles plow-shaped, with the tip truncated. Antennae 1.3 mm. in length; scape slender, subcylindrical; pedicle a little less than twice as long as wide at apex, and as long as the first funicle joint; funicle joints gradually widening and shortening distad; first three joints longer than wide, the first a little less than twice as long as wide, the fourth as long as wide, and the last two a little wider than long; club considerably wider than the last funicle joint, and a little longer than the last two funicle joints combined. Fore wings 2.16 mm. long by 0.83 mm. wide, and uniformly ciliated except hyaline parts; a group of long bristles just below the apical third of the submarginal vein; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 55 : 6 : 22 : 20. Hind wings 1.65 mm. in length and 0.51 mm. in width, and uniformly ciliated in the apical two-thirds. Middle tibiae with about 13 spines on the tip; hind tibiae with two unequal spurs.

Head, pronotum, mesoscutum, axillae and abdomen minutely, scaly reticulate; frontovertex with thimble-like punctures in sparse numbers; scutellum longitudinally strio-reticulate. Eyes bare; head with sparse numbers of short grey hairs; antennae with a few number of short brown hairs; pronotum, mesoscutum, axillae and abdomen with sparse black hairs; scutellum with a tuft of black bristles on the tip. Legs hairy.

Frontovertex, occiput, pronotum and mesoscutum except both the

lateral sides, axillae, extreme base and apical part of scutellum, metanotum and abdomen black; abdomen with a slight purplish reflection; cheeks and mandibles reddish brown; the lower part of face, lateral sides of pronotum and mesoscutum, tegulae, prepecti, mesopleurae, metapleurae and propodeon reddish brown with a touch of yellow, a broad transverse yellow band on the scutellum. Scape yellowish red; pedicle, funicle joints and club brown, the tip of the pedicle and the lower part of the funicle joints yellowish red. Fore wings infuscated in the apical two-thirds; a fuscous dot just below the apical two-thirds of the submarginal vein; veins brown except the base and apical third of the submarginal vein which are pale. Hind wings almost hyaline, faintly clouded near the anterior margin, the veins pale brown. Legs yellowish red-brown; fore coxae yellowish white; middle coxae, the base of the middle tibiae, the upper part of the hind coxae and femora, tibiae and tarsi dark brown; all of the trochanter brown.

Length of body, 2.7 mm.; width of thorax, 0.9 mm.

Male—Sculpture similar to that of the female. Antennae 1.44 mm. long; scape slender; pedicle as long as wide at apex; funicle joints subequal in length and width; club a little shorter than the last two funicle joints combined; funicle joints and club with rather thick, considerably long black hairs. Fore wings 1.88 mm. long by 0.79 mm. wide, and uniformly, thickly ciliated except the basal third; the parts surrounding the stigmal vein pale fuscous, much paler than in the female; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 50:6:23:18. Hind wings hyaline. Head and body black; scutellum with a broad yellow transverse band. Antennae yellowish brown, the tip of the scape deeper. The apical third of fore femora, tibiae and tarsi, apical part of middle tibiae and basal three joints of hind tarsi whitish yellow; middle tarsi except the terminal joint whitish; apical two joints of hind tarsi and apical joint of middle tibiae brownish; all of the coxae brown; the remaining parts of legs reddish brown.

Genitalia (Fig. 10) broad with slender lateral processes; clasper long with two short spines on the tip.



Length of body, 1.8 mm.; width of thorax, 0.63 mm.

Types in the author's collection.

A number of specimens of this new species were reared from *Kermes* sp. on *Celtis sinensis* in May, 1924 and 1926, and from *Takahashia* sp. on the same plant in June, 1926, Nagasaki. This species is very closely allied to the European species, *E. scutellata* (SWEDERUS), but differs from it in the color and the dimension of the antennal joints in the female.

***Eugahania* MERCET**

*Eugahania* MERCET, Eus. II (1926), No. 1, p. 43.

Notwithstanding the difference in the feature of the mandibles, this genus may be placed in the present tribe.

***Eugahania latiscapus* (ISHII)**

(Fig. 11.)

*Chalcaspis latiscapus* ISHII, Dept. Finance, Japan, Imp. Plant Quar. Serv., Tech. Bull. 3 (1925), p. 27.

This species was collected by sweeping at Nagasaki. Male genitalia (Fig. 11) stout with broad latera processes; clasper long with two spines on the tip.

Tribe III. **Mirini** ASHMEAD

The species belonging to this tribe are of various forms and can be distinguished from the other tribes chiefly by the mandibles which are usually tridentate or rarely quadridentate or have an upper truncated ridge and a lower tooth.

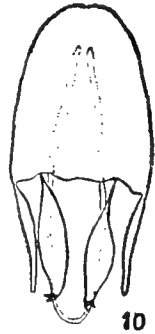


Fig. 10.  
*Encyrtus sarakii* sp.  
nov., genitalia  
of male.

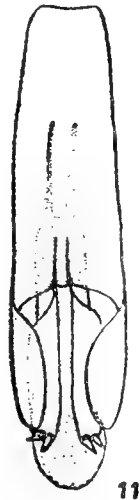


Fig. 11.  
*Eugahania latiscapus*  
(ISHII), genitalia  
of male.

## Key to the genera

## Female

1. Wings very small, degenerated ... .. *Microterys* THOMSON  
Wings normally developed ... .. 2
2. Antennae with the funicle 4 or 5-jointed ... .. 3  
Antennae with the funicle 6-jointed ... .. 4
3. Antennae with the funicle 4-jointed ... .. *Cymipencyrtus* g. nov.  
Antennae with the funicle 5-jointed ... .. *Psylledontus* CRAWFORD
4. Scutellum with a clump of hairs at apex ... .. 5  
Scutellum without a clump of hairs at apex ... .. 6
5. Antennae simple, neither much compressed nor broad ... .. *Cheiloncirus* WESTWOOD  
Antennae strongly compressed, broad ... .. *Faveusemion* ISHII
6. Antennae strongly compressed, broad ... .. 7  
Antennae neither strongly compressed nor broad ... .. 11
7. Fore wings fuscous, usually with the extreme tip white or hyaline ... *Anicetus* HOWARD  
Fore wings with fuscous rays or longitudinal bands ... .. 8
8. Scutellum flat, semicircular ... .. *Comperiella* HOWARD  
Scutellum more or less convexed, not semicircular ... .. 9
9. Head oblong ... .. 10  
Head short or lenticular ... .. *Cerapteroceroides* ASHMEAD
10. Submarginal vein with a triangular expansion at the apical third.  
*Cerapterocerus* WESTWOOD  
Submarginal vein without a triangular expansion at the apical third.  
*Metacerapterocerus* g. nov.
11. Submarginal vein with a triangular expansion at the apical third.  
*Tyndarichus* HOWARD  
Submarginal vein without a triangular expansion at the apical third ... .. 12
12. Head with the frons prominent, the face inflexed ... .. *Anabrotopsis* TIMBERLAKE  
Head as viewed from the side with the frons not prominent ... .. 13
13. Head lenticular ... .. 14  
Head not lenticular ... .. 15
14. Frontovortex and face with thimble-like punctures ... .. *Phacnodiscus* FÖRSTER  
Frontovortex and face with sparse punctures ... .. *Tachinaephagus* ASHMEAD
15. Mandibles with an upper truncated ridge and a lower pointed tooth ... .. 16  
Mandibles distinctly tridentate or with an upper truncated and two lower pointed  
teeth ... .. 19
16. Marginal vein longer than wide; scutellum more or less convexed ... .. 17  
Marginal vein junctiform; scutellum flattened ... .. *Metapronomitus* MERCEI
17. Mesoscutum with a scaly pubescence; tegulae whitish ... .. *Bla tethrix* MAYR

- Mesoscutum without a scaly pubescence; tegulae brown ... .. 18
18. Scutellum semicircular ... .. *Ooencyrtus* ASHMEAD  
 Scutellum triangular with round tip ... .. *Aphidencyrtoides* g. nov.
19. Mandibles distinctly tridentate ... .. 20  
 Mandibles with an upper truncated tooth and two lower pointed teeth.  
*Psyllazphagus* ASHMEAD
20. Wings thickly ciliated ... .. 21  
 Wings normally ciliated ... .. 22
21. Antennae elongate; funicle joints much longer than wide; wings long.  
*Heteroleptomastix* g. nov.  
 Antennae short, clavate; funicle joints much wider than long; wings broad.  
*Plesiomicraterys* g. nov.
22. Marginal vein punctiform ... .. 23  
 Marginal vein longer than wide ... .. 30
23. Antennae with club or some joints of funicle whitish or yellowish white ... .. 24  
 Antennae uniformly black or dark brown ... .. 29
24. Body yellowish, pale brown or black without metallic color ... .. 25  
 Body metallic color or black with some metallic parts ... .. 28
25. Club 3-jointed, ovate or lanceolate; scutellum flattened ... .. 26  
 Club entire, obliquely truncated from tip towards base; scutellum more or less convexed.  
*Isedromus* HOWARD
26. Postmarginal vein present ... .. 27  
 Postmarginal vein wanting ... .. *Astymachus* HOWARD
27. Funicle joints much wider than long ... .. *Aphyeus* MAYR  
 Funicle joints much longer than wide ... .. *Aenasioidea* GIRAULT
28. Mandibles equally tridentate ... .. *Homalotylus* MAYR  
 Mandibles unequally tridentate, the upper tooth small ... .. *Anisotylus* TIMBERLAKE
29. Club round at apex; stigmal vein cylindrical ... .. *Copidosoma* RATZEBURG  
 Club obliquely truncated; stigmal vein cuneiform ... .. *Litomastix* THOMSON
30. Fore wings with pale fuscous transverse bands; some joints of funicle whitish or  
 yellowish white ... .. *Microterys* THOMSON  
 Fore wings hyaline; antennae dark brown ... .. *Syrphophagus* ASHMEAD

### *Heteroleptomastix* gen. nov.

Female—Head wider than deep; mouth opening very wide; fronto-vertex very wide; occipital margin sharp; scrobes small, shallow, and not meeting above; cheeks rather short; malar suture distinct; labrum inconspicuous; mandibles robust, distinctly tridentate; maxillary palpi

four-jointed; labial palpi three-jointed. Antennae inserted a little below the middle of the face; scape moderately long and cylindrical; pedicle normal; funicle six-jointed, the joints cylindrical, much longer than wide, and shortening distad; club three-jointed, long ovate in shape, and pointed at tip. Pronotum short and narrow; axillae meeting at tip; scutellum comparatively small, triangle in shape with the tip rounded, and a small longitudinal median keel at the base; propodeon large. Abdomen ovate in shape, a little shorter than the thorax; first segment large, occupying nearly half of the abdomen; ovipositor short, the sheaths large. Fore wings long and very thickly ciliated except the hairless oblique line; marginal vein rather long, thrice as long as wide, a little shorter than the stigmal, and almost as long as the postmarginal. Hind wings thickly ciliated and with a trace of the basal nerve; submarginal cell very narrow. Legs slender; hind tibiae with two unequal spurs.

Face with sparse, large punctures.

Coloration yellowish red-brown or black; wings infuscated.

Genotype: *Heteroleptomastix miyama* sp. nov.

### **Heteroleptomastix miyama** sp. nov.

(Figs. 12-15.)

Female (Fig. 12)—Head wider than deep (45:40); frontovertex at the anterior ocellus as wide as about one half the width of the head; ocelli in an obtuse-angled triangle, the posterior pair separated from the eye margins and the occipital margin by a space a little less than their diameter; scrobes very shallow; a roundly elevated keel between the toruli; toruli separated from each other by one-eleventh the width of the head, and from the clypeal edge by a space a little less than their longitudinal diameter; cheeks very short, about one-sixth the length of the eyes; mandibles (Fig. 13) very robust, distinctly tridentate. Antennae (Fig. 14) 1.88 mm. in length; scape cylindrical, more or less swollen in the apical two-thirds, and a little shorter than the pedicle and first funicle joint combined; pedicle a little shorter than twice as long as wide at apex; funicle joints subcylindrical, much longer than wide, and gradually

decreasing in length and slightly increasing in width distad; first funicle joint five times as long as wide, and twice as long as the pedicle; last funicle joint twice as long as wide; club spindle-shaped, a little wider

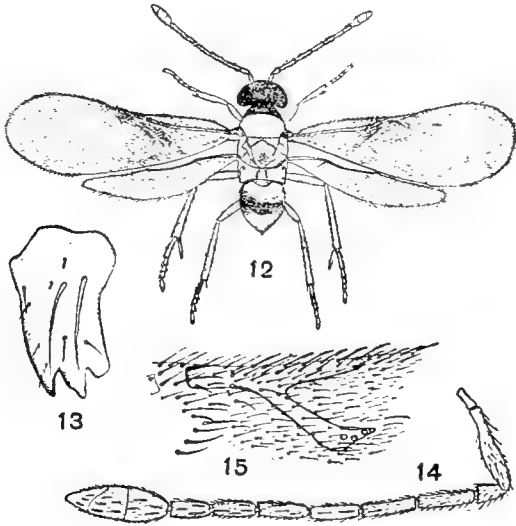


Fig. 12. *Heteroleptomastix miyama* sp. nov., female.  
 Fig. 13. Ditto, mandible of female.  
 Fig. 14. Ditto, antenna of female.  
 Fig. 15. Ditto, veins of fore wing of female.

than the last funicle joint, and considerably longer than the last two funicle joints combined. Fore wings 2.75 mm. in length and 0.83 mm. in width, and very thickly ciliated except the hairless oblique line and the basal part; submarginal, marginal, stigmal and postmarginal veins (Fig. 15) approximately in the ratio of 60 : 7 : 9 : 8; submarginal vein with about 30 bristles. Hind wings 1.95 mm. long by 0.42 mm. wide, and uniformly, thickly ciliated. Abdomen much shorter than the thorax. Middle tibiae with about 8 spines on the tip.

Head minutely, scaly reticulate; frontovertex with sparse, large punctures; pro- and meso-notum minutely, scaly reticulate; prepecti coarsely reticulate; mesopleurae rather smooth; propodeon smooth with several longitudinal striae in the middle; abdomen feebly reticulate. Eyes with very sparse pubescence; head with sparse numbers of grey hairs; antennae

with sparse brown hairs; pro- and meso-notum with few black hairs; metapleurae and abdomen with sparse grey hairs, the tip of the latter with long black hairs. Middle tibiae with thick grey hairs.

Body yellowish red-brown in general. Head black; pronotum, anterior margin of mesoscutum, metapleurae and abdomen except the basal third brownish black; tegulae brown with the tip paler; a large oblong brownish dot on the scutellum. Legs yellowish red. Antennae yellowish red-brown except the club which is brown. Fore wings infuscated, with the basal part paler; hind wings pale, infuscated, all the veins pale brown.

Length of body, 2.1 mm.; width of thorax, 0.65 mm.

This new species is based upon two female specimens collected by sweeping near Nagasaki in May, 1922, and at the foot of Mt. Ôyama, Kanagawa-ken in June, 1924.

### *Cynipencyrtus* gen. nov.

Female—Head longer than wide; frontovertex rather wide; eyes small, oval in shape; ocelli small; scrobes shallow; cheeks moderately long; occipital margin sharp; mandibles robust, distinctly tridentate; labrum small; maxillary palpi four-jointed; labial palpi three-jointed. Antennae inserted near the mouth border and composed of ten joints: scape, pedicle, two ring joints, five funicle joints and entire club. Scape moderately long, subcylindrical; pedicle rather long; funicle joints not longer than wide, the first joint very short, of a ring form; club entire, ovate in shape, and obliquely truncated at tip. Pronotum not very short, the anterior margin more or less truncated; axillae slightly separated; scutellum triangle in shape with round apex. Abdomen a little longer than the thorax, long ovate in shape. Ovipositor hidden. Fore wings uniformly ciliated except the hairless oblique line; marginal vein long, a little longer than the stigmal; postmarginal vein much longer than the stigmal. Hind wings uniformly ciliated; submarginal cell narrow. Hind tibiae with one spur on the tip; spines on the middle tibiae arranged in two rows.

Body more or less raised reticulate and yellowish in general.

Male—Similar to the female.

Genotype: *Cynipencyrtus flavus* sp. nov.

This genus is somewhat allied to *Accrophagus* E. A. SMITH.

***Cynipencyrtus flavus* sp. nov.**

(Figs. 16–22.)

Female (Fig. 16)—Head wider than deep (29:24); frontovertex at the anterior ocellus about as wide as five-eighths the width of the head; ocelli in an obtuse-angled triangle, the posterior pair separated from the eye margins by a space half their diameter and from the occipital margin by their diameter; scrobes shallow, extending to the middle of the face; mandibles (Fig. 18) robust, distinctly tridentate; cheeks as long as the

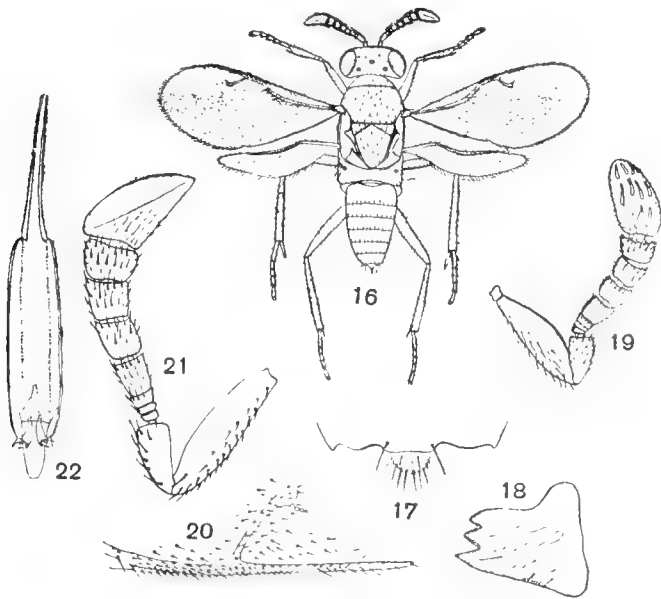


Fig. 16. *Cynipencyrtus flavus* sp. nov., female.

Fig. 17. Ditto, labrum of female.

Fig. 18. Ditto, mandible of female.

Fig. 19. Ditto, antenna of female.

Fig. 20. Ditto, veins of fore wing of female.

Fig. 21. Ditto, antenna of male.

Fig. 22. Ditto, genitalia of male.

eyes. Antennae (Fig. 19) 0.54 mm. long; scape rather cylindrical; pedicle twice as long as wide at apex; two ring joints subequal in length; first funicle joint rather ring-like in form, about one-third as long as the second; funicle joints 2-5 subequal in length, and increasing slightly in width distad; club obliquely truncated at tip, about as long as the last three funicle joints combined. Fore wings 1.13 mm. long by 0.42 mm. wide, and rather uniformly ciliated except the hairless oblique line; submarginal, marginal, stigmal and postmarginal veins (Fig. 20) approximately in the ratio of 31:8:6:14; submarginal veins with about 18 bristles. Hind wings uniformly ciliated. Abdomen shorter than the thorax. Middle tibiae with about 18 spines on the tip arranged in two rows.

Head, pro- and meso-notum minutely, more or less raised reticulate; mesopleurae longitudinally, minutely reticulate; propodeon and abdomen feebly reticulate. Antennae with sparse, short brownish hairs; pro- and meso-notum and abdomen with sparse black hairs.

Body orange yellow in general. A black spot beneath the spur of the fore tibiae; the apex of all the legs brownish. Wings hyaline, the veins yellowish. Abdominal segments 2-5 with a brownish band near the base.

Length of body, 1.28 mm.; width of thorax, 0.45 mm.

Male—Similar to the female. Abdominal segments 2-5 without brownish band near the base. Genitalia (Fig. 22) rather stout with small lateral processes; clasper with one spine on the tip.

Types in the author's collection.

This new species is based upon two specimens, a female and a male, reared from the Cynipid gall on *Quercus serrata*, June, 1923, and August, 1924, Nagasaki.

### ***Cynipencyrtus bicolor* sp. nov.**

Female—Head as wide as deep; frontovertex at the anterior ocellus as wide as a little more than the width of the head; ocelli very small, in an obtuse-angled triangle, the posterior pair separated from the eye margins by a space twice their diameter and from the occipital margin



by one half their diameter; scrobes shallow, meeting above; cheeks as long as one half the length of the eyes; mandibles robust, distinctly tridentate, the lower tooth larger. Antennae 0.68 mm. in length, similar to those of *C. flavus*, and inserted at the level of the lower corner of the eyes; scape slender, rather cylindrical; pedicle twice as long as wide at apex, almost as long as the two ring joints and first funicle joint combined; first funicle joint very short, wider than long; funicle joints 2-5 subequal in length and width, a little longer than wide; club obliquely truncated at tip, a little wider than the last funicle joint, and as long as the last three funicle joints combined. Pronotum nearly as wide as the mesoscutum, as long as one-third the length of the latter; mesoscutum wider than long; axillae meeting; scutellum a little longer than wide or the mesoscutum; abdomen as long as the thorax; ovipositor slightly produced. Fore wings 2.25 mm. long by 0.86 mm. wide, and uniformly ciliated except the hairless oblique line; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 60:20:14:27; submarginal vein with about 24 bristles. Hind wings uniformly ciliated.

Head minutely reticulate; pro- and meso-notum more or less raised reticulate; mesopleurae rather smooth; propodeon and abdomen feebly reticulate. Head, pro- and meso-notum with sparse, short black hairs.

Body orange yellow in general. Antennae orange yellow with sparse, short black hairs; mandibles orange yellow with the tip dark brown; mesopleurae yellowish red; propodeon brown; the apical half of scutellum pale brown; abdomen brownish black except the extreme base which is reddish yellow. Wings hyaline, the veins yellowish. Legs yellowish except the apical two-thirds of the hind femora which is brownish; the apex of all the legs brown.

Male—Unknown.

Types in the author's collection.

This new species is represented by two females collected on *Quercus serrata* near Nagasaki in May and June, 1926.

***Metaprionomitus* MERCET**

*Metaprionomitus* MERCET, Fauna Ibérica, Encirt., 1921, p. 260.

***Metaprionomitus nipponicus* sp. nov.**

Female—Head a little wider than deep (30:28); frontovertex at the anterior ocellus as wide as two-fifths the width of the head; ocelli in an obtuse-angled triangle, the posterior pair separated from the eye margins and the occipital margin by one half their diameter; scrobes moderately deep; mandibles with an upper truncated ridge and a lower tooth. Antennae 0.44 mm. in length; scape moderately dilated towards the tip; pedicle twice as long as wide at apex, almost as long as the first two funicle joints combined; funicle joints subequal in length except the first joint which is a little shorter, and increasing in width distad; first funicle joint as long as wide, the last joint a little wider than long; club considerably wider than the last funicle joint, and almost as long as the last three funicle joints combined. Axillae meeting; scutellum flat. Fore wings 1.28 mm. in length and 0.51 mm. in width, and ciliated uniformly except the basal part; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 28:3:6:2; submarginal vein with about 14 bristles. Abdomen a little shorter than the thorax; ovipositer about one-fifth the length of the abdomen.

Body bluish green in general. Face with a strong purplish reflection; tegulae black except the base which is whitish; metanotum, propodeon and abdomen black, the basal sides of the abdomen with a greenish blue reflection; ovipositor black. Antennae brownish black, the scape and pedicle much deeper. Wings hyaline, the veins pale brown. Legs yellowish white except the coxae and hind femora which are black except the tip; fore tarsi brownish yellow; the apical joint of hind tarsi brownish.

Length of body, 1.1 mm.; width of thorax, 0.45 mm.

Male—Unknown.

Type in the author's collection.

This new species is based upon a single specimen collected on *Ficus*

*foveolata* at Ikiriki, Nagasaki-ken, in November, 1924.

***Psylledontus* CRAWFORD**

*Psylledontus* CRAWFORD, Proc. U. S. Nat. Mus., XXXVIII (1910), p. 88.

***Psylledontus viridiscutellatus* sp. nov.**

(Figs. 23-25.)

Female—Head a little wider than deep (35 : 32); frontovertex at the anterior ocellus as wide as a little more than one-third the width of the head; ocelli in an obtuse-angled triangle, the posterior pair near to the

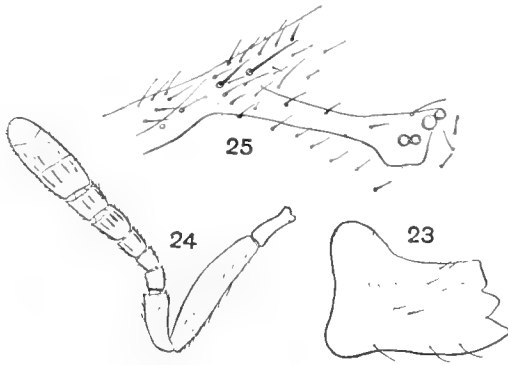


Fig. 23. *Psylledontus viridiscutellatus* sp. nov., mandible of female.

Fig. 24. Ditto, antenna of female.

Fig. 25. Ditto, veins of fore wing of female.

eye margins and separated from the occipital margin by their diameter; scrobes moderately deep, reaching considerably above the middle of the face; mandibles (Fig. 23) tridentate, the teeth not sharp, and the upper tooth truncated; maxillary and labial palpi tridentate. Antennae (Fig. 24) 0.72 mm. in length; scape moderately long, cylindrical; pedicel long, thrice as long as wide at apex, and as long as the first three funicle joints combined; funicle five-jointed, the joints as long as wide, increasing gradually in length and width distad; club three-jointed, a little wider than the last funicle joint, and almost as long as the last three funicle joints combined. Axillae meeting at tip; scutellum flat, triangular in shape, as long as wide and mesoscutum.

Fore wings 1.08 mm. in length and 0.41 mm. in width, and uniformly ciliated except the basal third; submarginal, marginal, stigmal and post-marginal veins (Fig. 25) approximately in the ratio of 26:7:4:2; submarginal vein with about 19 bristles. Hind wings uniformly ciliated. Abdomen a little shorter than the thorax. Middle tibiae with about 6 spines on the tip.

Head except the frontovertex, pro- and meso-notum except the scutellum and abdomen minutely, scaly reticulate; frontovertex raised reticulate, with sparse shallow punctures; scutellum longitudinally strio-reticulate. Eyes pubescent; pro- and meso-notum and abdomen with sparse brown hairs.

Body black in general. Antennae dark brown with sparse short brownish hairs; the extreme tip and base of scape, the tip of pedicel and club yellowish; face with a purplish reflection; scutellum with a strong greenish reflection; abdomen with a slight purplish reflection, the base with a greenish reflection. Wings hyaline, the veins pale brown. All the coxae, femora except the tip and base, fore and hind tibiae except both the base and apical third, and a band near the base of the middle tibiae dark brown, the remainder of all the legs yellowish.

Length of body, 1.43 mm.; width of thorax, 0.53 mm.

Male—Similar to the female except the following characters: club entire; scutellum with a greenish blue reflection; body much smaller.

Length of body, 0.83 mm.; width of thorax, 0.4 mm.

Types in the author's collection.

This new species is based on two specimens reared from a Psyllid on *Elacagnus umbellata* at Okusa, Nagasaki-ken, in June, 1926. It can be distinguished from *Psylledontus insidiosus* CRAWFORD by the club which is three-jointed in the female.

### *Copidosoma* RATZBURG

*Copidosoma* RATZBURG, Ich. d. Forstins., I (1844), p. 157; MAYR, Verh. k. k. zool.-bot. Ges. Wien, XXV (1875), p. 731; SCHMIDTKEICH, Gen. Ins., XCVII (1909), p. 223; ASHFAD, Proc. U.S. Nat. Mus., XXII (1900), p. 366; MURCE, Fauna Ibérica, Fucit., 1921, p. 365.

*Litomastix* THOMSON, Hym. Scand., IV. (1875), p. 171.

*Neocopidosoma* ISHII, Dept. Agr. & Comm. Japan, Imp. Plant Quar. Sta., Bull. 3 (1923), p. 101.

### **Copidosoma komabae** (ISHII)

*Neocopidosoma komabae* ISHII, Dept. Agr. & Comm. Japan, Imp. Plant Quar. Sta., Bull. 3 (1923), p. 102.

This species was reared from a Tortricid-larva on *Elacagnus umbellata* at Komaba near Tôkyô.

### **Copidosoma japonicum** ASHMEAD

*Copidosoma japonicum* ASHMEAD, Journ. N. Y. Entom. Soc., XII (1904), p. 154.

This species was collected by Mr. Y. NAWA at Gihu. Host unknown.

### **Copidosoma convexum** sp. nov.

(Figs. 26 and 27.)

Female—Head longer than wide (22 : 19); frontovertex at the anterior ocellus as wide as a little more than one half the width of the head; ocelli in an obtuse-angled triangle, the posterior pair very near to the eye margins and separated from the occipital margin by their diameter; cheeks moderately long; face convex; scrobes indistinct; mandibles distinctly tridentate. Antennae (Fig. 26) 0.68 mm. in length; scape

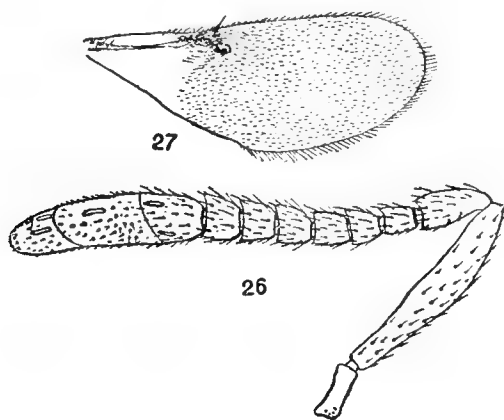


Fig. 26. *Copidosoma convexum* sp. nov., antenna of female.  
Fig. 27. Ditto, fore wing of female.

slender; pedicel a little more than twice as long as wide at apex; funicle joints subequal in length, widening distad; first joint a little longer than wide, and a little less than one half the length of the pedicel; club very long, almost as long as the funicle. Fore wings (Fig. 27) 0.86 mm. in length and 0.32 mm. in width, and ciliated uniformly except the basal third; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 19 : 3 : 3 : 0; submarginal vein with about 8 bristles. Abdomen a little shorter than the thorax, considerably compressed; ovipositor about one-fourth the length of the abdomen. Middle tibiae with about 4 spines on the tip.

Face and frontovertex large, raised reticulate; cheeks longitudinally strio-reticulate; pro- and meso-notum and mesopleurae largely reticulate; abdomen feebly reticulate.

Black with a greenish reflection. Antennae black with sparse numbers of short black hairs; mesopleurae and abdomen with a slight purplish reflection; ovipositor brown. Fore wings hyaline with a fuscous dot just below the marginal vein and a paler one at the base; veins pale brown. Hind wings hyaline. Fore legs brownish black except the tarsi which are pale brown. The tip and base of middle femora and hind tarsi except the last joint whitish; the base and apical third of middle tibiae, and spur and tarsi of middle legs whitish yellow; all the terminal joints of the tarsi brown; the remainder of all the legs black.

Length of body, 1.07 mm., width of thorax, 0.32 mm.

Male—Unknown.

Type in the author's collection.

This new species is based upon only one specimen collected by sweeping near Nagasaki in August, 1923.

### *Litomastix* THOMSON

*Litomastix* THOMSON, Hym. Scand., IV (1875), p. 171; ASHMEAD, Proc. U. S. Nat. Mus., XXII (1900), p. 363; SCHMIDTKNECHT, Gen. Ins., XCVII (1909), p. 225; MERCIET, Fauna Ibérica, Encirt., 1924, p. 441.

*Copilema* MAYR, Verh. k. k. zool.-bot. Ges. Wien, XXV (1875), p. 731.

**Litomastix maculata** sp. nov.

Female—Head as wide as deep; frontovertex at the anterior ocellus as wide as one half the width of the head; ocelli in an obtuse-angled triangle, the posterior pair separated from the eye margins and the occipital margin by their diameter; scrobes moderately deep; mandibles distinctly tridentate, the lower tooth larger. Antennae 0.65 mm. in length; scape slender; pedicle a little more than twice as long as wide at apex, and as long as the first three funicle joints combined; funicle joints gradually increasing in width and length distad, the first joint as long as wide; club solid, obliquely truncated, and as long as the last five funicle joints combined. Fore wings 1.05 mm. long by 0.48 mm. wide, and uniformly ciliated except the basal third; submarginal, marginal, stigmal and post-marginal veins approximately in the ratio of 24 : 3 : 4 : 2; submarginal vein with about 10 bristles. Middle tibiae with about 4 spines on the tip. Head, axillae and mesopleurae minutely reticulate; mesoscutum largely reticulate; scutellum longitudinally, coarsely reticulate.

Body black in general. Mesoscutum and tip of scutellum with a greenish reflection; axillae, scutellum and mesopleurae with a slight purplish reflection. Antennae brownish black. Fore wings hyaline with a pale fuscous dot just below the marginal vein. The apex of fore and middle femora, base of all the tibiae and spur whitish yellow; fore and middle tarsi pale brown; fore and hind tarsi brownish.

Length of body, 0.87 mm.; width of thorax, 0.3 mm.

Male—Unknown.

Types in the author's collection.

This new species is allied to the European species, *L. truncatellum* (DALM.), but may be distinguished from it by the fore wings which have a pale fuscous dot as well as by the sculpture of the head and the thoracic notum. The material was collected by sweeping at Ozuki, Kanagawa-ken, in June, 1923.

**Anisotylus** TIMBERLAKE

*Anisotylus* TIMBERLAKE, Proc. U. S. Nat. Mus., LVI (1919), p. 170.

**Anisotylus albifrons** ISHII

*Anisotylus albifrons* ISHII, Dept. Finance, Japan, Imp. Plant Quar. Serv., Tech. Bull. 3 (1925), p. 28.

This species was reared from the larvae of *Scymnus* sp. feeding on the larvae of *Pseudococcus* sp. on the citrus tree at Nagasaki.

**Homalotylus** MAYR

*Homalotylus* MAYR, Verh. k. k. zool.-bot. Ges. Wien, XXV (1875), p. 752; ASHMEAD, Proc. U. S. Nat. Mus., XXII (1900), p. 377; SCHMIEDEKNECHT, Gen. Ins., XCVII (1909), p. 235; TIMBERLAKE, Proc. U. S. Nat. Mus., LVI (1919), p. 134; MERCET, Fauna Ibérica, Encirt., 1921, p. 515.

*Nobrimus* THOMSON, Hym. Scand., IV (1875), pp. 116 & 137.

**Homalotylus flaminus** (DALMAN)

(Fig. 28.)

*Homalotylus flaminus* MAYR, Verh. k. k. zool.-bot. Ges. Wien, XXV (1875), p. 753; MASI, Boll. Lab. Zool. Portici, I (1907), p. 288; TIMBERLAKE, Proc. U. S. Nat. Mus., LVI (1919), p. 141; MERCET, Fauna Ibérica, Encirt., 1921, p. 519.

*Nobrimus flaminus* THOMSON, Hym. Scand., IV (1875), p. 138.

This species was reared from the larvae of *Chilocorus kuwanai* SILV. and *Coccinella bruckii* MULS. found at Nagasaki.

Male genitalia (Fig. 28) rather stout, without lateral process; clasper with three considerably large spines on the tip.

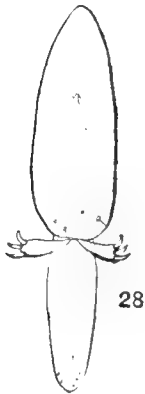


Fig. 28.

*Homalotylus flaminus* (DALM.), genitalia of male.

**Isodromus** HOWARD

*Isodromus* TIMBERLAKE, Proc. U. S. Nat. Mus., LVI (1919), p. 176; SCHMIEDEKNECHT, Gen. Ins., XCVII (1909), p. 236.



**Isodromus axillaris** TIMBERLAKE

*Isodromus axillaris* TIMBERLAKE, Proc. U. S. Nat. Mus., LVI (1919), p. 183.

This species was reared from the cocoons of *Chrysopa boninensis* collected near Nagasaki in April, 1923. It was also collected by A. KOEBELE in China. The specimens from Japan agree with the original form, exclusive of the presence in the male of a black spot on the tip of the scutellum, much as in the female.

**Blastothrix** MAYR

*Blastothrix* MAYR, Verh. k. k. zool.-bot. Ges. Wien, XXV (1875), p. 697; ASHMEAD, Proc. U. S. Nat. Mus., XXII (1900), p. 389; SCHMEDEKNECHT, Gen. Ins., XCVII (1909), p. 240; MERCET, Fauna Ibérica, Encirt., 1921, p. 242.

*Microterys* THOMSON (part), Hym. Scand., IV (1875), p. 155.

**Blastothrix kermivora** sp. nov.

(Figs. 29 and 30.)

Female—Head wider than deep (35 : 30); frontovertex at the anterior ocellus as wide as one-third the width of the head; ocelli in an obtuse-angled triangle, the posterior pair separated from the eye margins by one half their diameter and from the occipital margin by twice their diameter; scrobes rather shallow; mandibles with an upper truncated ridge and a lower tooth. Antennae (Fig. 29) 1 mm. in length; scape much dilated below; pedicle twice as long as wide at apex; funicle joints longer than wide, subequal in length, slightly increasing in width distad, the first and second joints a little shorter, and the first joint as long as the pedicle; club considerably wider than the last funicle joint, a little longer than the last two funicle joints combined.

Fore wings 1.5 mm. long by 0.6 mm. wide, and ciliated uniformly except the basal third; submarginal, marginal, stigmal and postmarginal veins

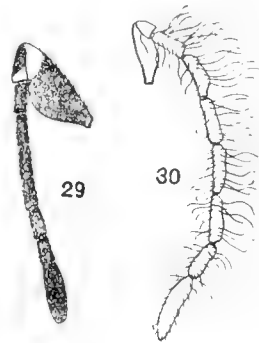


Fig. 29. *Blastothrix kermivora* sp. nov., antenna of female.

Fig. 30. Ditto, antenna of male.

approximately in the ratio of 32:5:7:5; submarginal vein with about 12 bristles. Abdomen a little shorter than the thorax; ovipositor a little more than one-fifth the length of the abdomen. Middle tibiae with about 6 spines on the tip.

Head, pro- and meso-notum minutely raised reticulate; mesopleurae minutely reticulate; abdomen coarsely raised reticulate.

Head, pro- and meso-notum dark blue with a greenish reflection; tegulae except the tip and the posterior margin of prepecti whitish, the tip of the tegulae pale brown; metanotum, propodeon and abdomen except the venter which is yellowish brown, and mesopleurae red-brown with a touch of yellow; ovipositor pale brown. Antennae brownish black except the tip of the scape and pedicle which are whitish. Wings hyaline, the veins pale brown. Fore legs whitish except the basal half of coxae, a large spot on the inner margin of femora and a spot on the basal third of outer margin of tibiae brownish; middle legs whitish, the coxae and a spot on the base of the outer margin of the tibiae brown; hind legs with coxae yellowish red-brown; femora pale brown except the tip and base which are yellowish white; a brown spot near the base and apex of the outer margin of the tibiae pale. The apex of all the legs brownish. Head, pro- and meso-notum, metapleurae and basal part of abdomen with somewhat scaly, whitish hairs in sparse numbers.

Length of body, 1.35 mm.; width of thorax, 0.53 mm.

Male—Head wider than deep (34:30); frontovertex at the anterior ocellus as wide as a little more than one-third the width of the head; the posterior pair of ocelli separated from the eye margins and the occipital margin by their diameter; scrobes moderately deep; mandibles similar to those of the female. Antennae (Fig. 30) 1.1 mm. in length; scape much dilated below; pedicle as long as wide at apex; funicle joints longer than wide, subequal in width, the first funicle joint twice as long as the pedicle, joints 2-5 subequal in length, a little longer than the first joint, and the sixth as long as the first; club a little shorter than the last two funicle joints combined. Fore wings 1.4 mm. in length and 0.65 mm. in width, and ciliated uniformly except the basal third; submarginal, marginal,

stigmal and postmarginal veins approximately in the ratio of 32:5:6:7; middle tibiae with about 5 spines on the tip. Sculpture and coloration almost similar to those of the female. Mesopleurae and venter of abdomen brownish black. Antennae yellowish brown, the scape and pedicle except the tip respectively black; funicle and club with sparse, long brown hairs. Wings hyaline, the veins pale brown. Legs yellowish white in general. All the coxae brownish black except the tip; a spot near the base of the outer margin of the middle tibiae, hind femora and tibiae without the tip and base respectively, and the last joint of all the tarsi brownish.

Length of body, 1.28 mm.; width of thorax, 0.48 mm.

Types in the author's collection.

Reared from *Kermes natvae* and *K. miyasakii* found in Kanagawa-ken in May, 1923.

#### **Blastothrix ozukiensis** sp. nov.

Female—Head much wider than deep (36:27); frontovertex at the anterior ocellus as wide as a little more than one-third the width of the head; ocelli in an obtuse-angled triangle, the posterior pair separated from the eye margins by their diameter and from the occipital margin by one half the diameter; scrobes rather shallow; mandibles similar to those of the preceding species. Antennae 0.83 mm. in length; scape much dilated below, about twice as long as wide at the widest portion; pedicle a little longer than wide at apex; funicle joints longer than wide, slightly increasing in width distad, the first joint almost as long as the pedicle, a little less than twice as long as wide, joints 1-5 subequal in length and the sixth a little shorter than the last three funicle joints combined. Fore wings 1.43 mm. in length and 0.66 mm. in width, and ciliated uniformly except the basal third; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 33:4:6:8; submarginal vein with about 14 bristles. Abdomen much shorter than the thorax; ovipositor slightly produced. Middle tibiae with about 5 spines on the tip.

Body black in general. Head, pro- and meso-notum with a greenish reflection, and with sparse, scaly whitish hairs; mesopleurae, metanotum,

propodeon and abdomen black; tegulae whitish with the tip pale brown. Antennae dark brown except the scape and pedicle which are black. Wings hyaline, the veins pale brown except the postmarginal vein which is paler. Fore legs black except the tarsi which are brown; middle legs pale yellowish brown, the coxae black, the knee, tibial spur and tarsi whitish, and a brownish annulus at the base of the tibiae; hind legs black, the knee whitish yellow, the tip of the tibiae and tarsi pale yellowish brown. Sculpture similar to that of *B. kermivora*.

Length of body, 1.14 mm.; width of thorax, 0.53 mm.

Male—Unknown.

Type in the author's collection.

This new species is based upon a single specimen collected by sweeping at Ozuki, Kanagawa-ken, in June, 1923.

### ***Astymachus* HOWARD**

*Astymachus* HOWARD, Proc. U. S. Nat. Mus., XXI (1898), p. 238; ASHMEAD, Proc. U. S. Nat. Mus., XXII (1900), p. 389.

### ***Astymachus japonicus* HOWARD**

*Astymachus japonicus* HOWARD, Proc. U. S. Nat. Mus., XXI (1898), p. 239.

This species was reared first by A. KOEBELE from a *Lecanium*-like Coccid found on *Bambusa* at Gihu, and then by C. P. CLAUSEN from *Aclerda japonica* on the same host near Nagasaki.

### ***Aenasioidea* GIRAULT**

*Aenasioidea* GIRAULT, Can. Ent., XLIII (1911), p. 171; TIMBERLAKE, Proc. U. S. Nat. Mus., L (1916), p. 579.

### ***Aenasioidea tenuicornis* TIMBERLAKE**

*Aenasioidea tenuicornis* TIMBERLAKE, Proc. U. S. Nat. Mus., L (1916), p. 581.

This species was reared by I. KUWANA from *Kermes miyasakii* KUWANA obtained at Akabane in August, 1909.

**Aphycus** MAYR

*Aphycus* MAYR, Verh. k. k. zool.-bot. Ges. Wien, XXV (1875), p. 695; ASHMEAD, Proc. U. S. Nat. Mus., XXII (1900), p. 383; SCHMIEDERKNECHT, Gen. Ins., XCVII (1909), p. 203; TIMBERLAKE, Proc. U. S. Nat. Mus., L (1916), p. 787; MERCET, Fauna Ibérica, Encirt., 1921, p. 194.

*Microterys* THOMSON (part), Hym. Scand., IV (1875), p. 155.

**Key to the species****Female**

1. Wings without tegumentary marking ... .. 2  
Wings with a tegumentary marking.  
Scape not expanded; antennae entirely yellowish white ... .. *albicornis* TIMB.  
Scape expanded, club black, the preceding joint whitish ... .. *timberlakei* ISHII
2. Ocelli in an equi-lateral triangle ... .. *albopleuralis* ASHMEAD  
Ocelli in an acute-angled triangle.  
Club as long as the last four funicle joints combined ... .. *pulvinariae* HOWARD  
Club as long as all the funicle joints combined ... .. *orientalis* H. COMPERE

**Male**

1. Wings with a tegumentary marking ... .. *timberlakei* ISHII  
Wings without tegumentary marking ... .. 2
2. Club as long as the last three funicle joints combined ... .. 3  
Club as long as the last four funicle joints combined ... .. *orientalis* H. COMPERE
3. Mesoscutum dark brown ... .. *pulvinariae* HOWARD  
Mesoscutum orange yellow ... .. *albopleuralis* ASHMEAD

**Aphycus albopleuralis** ASHMEAD

(Fig. 31.)

*Aphycus albopleuralis* ASHMEAD, Journ. N. Y. Entom. Soc., XII (1904), p. 155;  
TIMBERLAKE, Proc. U. S. Nat. Mus., L (1916), p. 612.

The specimens in hand were collected by Y. NAWA and also reared by the writer from *Kermes* sp. on the cherry tree at Nagasaki in May.

Male—Head considerably wider than deep (39:32); frontovortex at the anterior ocellus as wide as one-third the width of the head; ocelli in an obtuse-angled triangle, the posterior pair separated from the eye margins and the occipital margin by their diameter; scrobes rather shallow;

mandibles tridentate. Antennae (Fig. 31) 0.83 mm. in length; scape dilated below; pedicle a little more than twice as long as wide at apex, a little shorter than the first three funicle joints combined; funicle joint wider than long, increasing in width and length, the last joint twice as wide as the first; club a little wider than the last funicle joint, almost as long as the last three funicle joints combined. Fore wings 1.5 mm. long by 0.63 mm. wide, and uniformly ciliated. Sculpture and coloration similar to those of the female except the antennae which are brown and have the scape with the whitish yellow upper margin and outer part as well as with the brownish inner part; pedicle paler towards the tip.

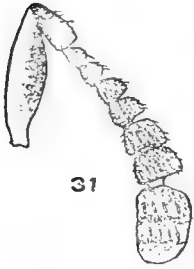


Fig. 31.  
*Aphycus albofleuralis*  
ASHM., antenna  
of male.

Length of body, 1.32 mm.; width of thorax, 0.39 mm.

### ***Aphycus albicornis* TIMBERLAKE**

*Aphycus albicornis* TIMBERLAKE, Proc. U. S. Nat. Mus., L (1916), p. 594.

This species was reared by C. L. MARLATT from *Pulvinaria* sp. found at Ikeda, near Kōbe, in May, 1901.

### ***Aphycus orientalis* H. COMPÈRE**

*Aphycus orientalis* H. COMPÈRE, Bull. South. Calif. Acad. Sci., XXIII (1924), pt. 4, p. 120.

This species is parasitic of *Coccus pseudomagnoliarum* (KUWANA) and *C. hesperidum* (L.) and was found near Yokohama.

### ***Aphycus pulvinariae* HOWARD**

*Aphycus pulvinariae* TIMBERLAKE, Proc. U. S. Nat. Mus., L (1916), p. 618.

*Aphycus* (*Euaphycus*) *pulvinariae* MARLATT, Fauna Ibérica, Encirt., 1921, p. 211.

This species was reared from *Coccus hesperidum* (L.) and *Eulecanium* sp. found on *Euonymus europaea* and *Vitis vinifera* near Nagasaki and also at Odawara, Kanagawa-ken, in August, 1922, and April, 1926. It is of very wide distribution, being found in North America and Spain.

**Aphycus timberlakei** ISHII

(Fig. 32.)

*Aphycus timberlakei* ISHII, Dept. Agr. & Comm. Japan, Imp. Plant Quar. Sta., Bull. 3 (1923), p. 108.

This species was reared from *Eulcanium* sp. found on *Euonymus europæa* at Nagasaki. Genitalia (Fig. 32) stout, with small lateral processes; clasper with two spines on the tip.

**Tachinaephagus** ASHMEAD

*Tachinaephagus* ASHMEAD, Mem. Carnegie Mus., I (1904), p. 304.

**Tachinaephagus fuscipennis** ASHMEAD

*Tachinaephagus fuscipennis* ASHMEAD, Journ. N. Y. Entom. Soc., XII (1904), p. 155.

This species was recorded by A. KOEBELE from Atami and Hakone.



Fig. 32.  
*Aphycus timberlakei* ISHII,  
genitalia of male.

**Aphidencyrtoides** gen. nov.

Closely allied to the genus *Aphidencyrtus* ASHMEAD, but differs from it in the mandibles and wing veins.

Genotype: *Aphidencyrtoides thoracaphis* sp. nov.

**Aphidencyrtoides thoracaphis** sp. nov.

(Figs. 33-37.)

Female—Head wider than deep (38:33); frontovertex at the anterior ocellus as wide as a little more than one-third the width of the head; eyes occupying about two-thirds the depth of the head; ocelli in an obtuse-angled triangle, the posterior pair near to the eye margins and separated from the occipital margin by their diameter; scrobes moderately deep, reaching the middle of the face; toruli separated from each other by a little more than one-third the width of the head and from the clypeal edge by their length; mouth-opening as wide as one-third the width of the

head. Mandibles (Fig. 33) with an upper broad truncated edge and a lower tooth. Antennae (Fig. 34) 0.74 mm. in length; scape slightly

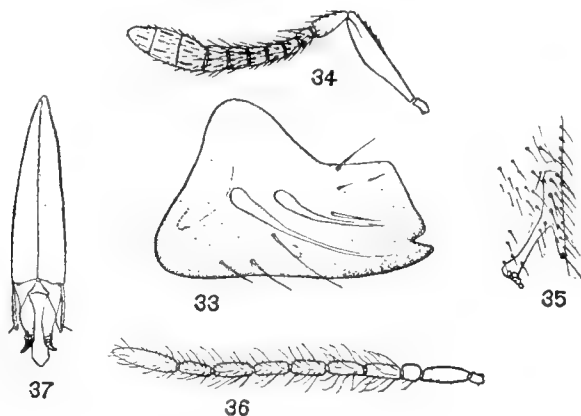


Fig. 33. *Aphicencyrtoides thoracaphis* sp. nov., mandible of female.  
 Fig. 34. Ditto, antenna of female.  
 Fig. 35. Ditto, veins of fore wing of female.  
 Fig. 36. Ditto, antenna of male.  
 Fig. 37. Ditto, genitalia of male.

dilated below; pedicle almost twice as long as wide, and as long as the first two funicle joints combined; funicle joints slightly increasing in width and length distad, the first joint as long as wide, and the last joint slightly wider than long; club slightly wider than the last funicle joint and slightly longer than the last three funicle joints combined. Fore wings (Fig. 35) 1.5 mm. long by 0.68 mm. wide, and uniformly ciliated except the basal third; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 33:4:6:3; submarginal vein with about 13 bristles. Middle tibiae with about 6 spines on the tip.

Body black with a slight blue reflection. Checks and mesopleurae with a slight purplish reflection; metanotum, propodeon and abdomen black. Antennae brown, the scape and pedicel darker. Wings hyaline, the veins pale brown except the marginal vein and the base of the stigmal vein which are dark brown. The tip of fore femora, base and tip of fore tibiae, fore tarsi and tip of middle femora yellowish brown; the apical third of middle tibiae, spur of middle tibiae and middle tarsi yellowish; the tip



of hind tarsi whitish yellow; all the last tarsal joints brown; the remaining parts of legs black.

Head, pro- and meso-notum scaly reticulate except the scutellum which is raised reticulate; mesopleurae minutely reticulate; metanotum and propodeum transversely reticulate; abdomen feebly reticulate. Antennae with sparse, short brown hairs. Head, pro- and meso-notum and abdomen with brown hairs in sparse numbers.

Length of body, 0.9 mm.; width of thorax, 0.45 mm.

Male—The sculpture and coloration similar to those of the female. Antennae (Fig. 36) 0.65 mm. in length; scape short, somewhat dilated below; pedicel as long as wide at apex, one half as long as the first funicle joint; funicle joints subcylindrical, subequal in length except the first which is slightly longer, and each joint longer than wide; club solid, elongate-oval in shape, pointed at tip, and slightly longer than the last three funicle joints combined. Funicle and club with sparse, considerably long, brown hairs. Fore wings 1.13 mm. in length and 0.53 mm. in width; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 28:2:4:3.

Genitalia (Fig. 37) rather stout, with small lateral processes; clasper with one stout spine.

Length of body, 0.9 mm.; width of thorax, 0.45 mm.

Types in the author's collection.

A number of specimens were reared from *Thoracaphis* sp. found on *Quercus glauca* near Nagasaki in May, 1925 and 1926.

### ***Ooencyrtus* ASHMEAD**

*Ooencyrtus* ASHMEAD, Proc. U. S. Nat. Mus., XXII (1900), p. 381; SCHMIEDEKNECHT, Gen. Ins., XCVII (1909), p. 238; MERCET, Fauna Ibérica, Encirt., 1921, p. 297.

*Schedius* HOWARD, U. S. Dept. Agr. Bur. Ent., Techn. Ser., No. 19 (1910), pt. 1, p. 2; MERCET, Fauna Ibérica, Encirt., 1921, p. 305.

### ***Ooencyrtus* (*Schedius*) *kuvanae* (HOWARD)**

*Schedius kuvanae* HOWARD, U. S. Dept. Agr. Bur. Ent., Techn. Ser., No. 19 (1910), pt. 1, p. 3.

This species is one of the important egg parasites of *Porthettia dispar* in Japan. It has been imported into the United States and has been established there.

**Ooencyrtus (Ooencyrtus) nezarae** sp. nov.

(Figs. 38 and 39.)

Female—Head a little wider than deep (23:21); frontovertex at the anterior ocellus as wide as a little less than one-third the width; ocelli in an obtuse-angled triangle, the posterior pair separated from the eye margins by one half their diameter and from the occipital margin by

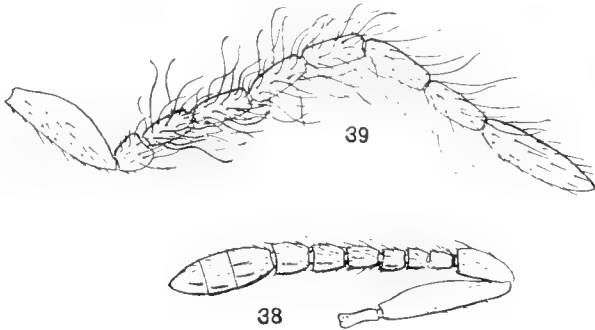


Fig. 38. *Ooencyrtus nezarae* sp. nov., antenna of female.

Fig. 39. Ditto, antenna of male.

their diameter; scrobes moderately deep, reaching just below the anterior ocellus; occipital margin acute; mandibles with an upper broad truncated ridge and a lower tooth. Antennae (Fig. 38) 0.56 mm. in length; scape rather slender, slightly dilated below in the middle; pedicel twice as long as wide at apex, slightly longer than the first two funicle joints combined; funicle joints slightly longer than wide except the third which is as long as wide, and gradually increasing in length and width distad; club slightly wider than the last funicle joint, and almost as long as the last three funicle joints combined. Fore wings 0.9 mm. in length and 0.39 mm. in width, and uniformly ciliated except the basal third; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 20:2:3:1; submarginal vein with about 17 bristles. Middle tibiae with

about 4 spines on the tip. Ovipositor slightly produced.

Head minutely strio-reticulate except the frontovertex which is more or less raised reticulate; pronotum and mesoscutum rather coarsely reticulate; axillae minutely, scaly reticulate; scutellum longitudinally strio-reticulate; mesopleurae longitudinally, minutely strio-reticulate; abdomen feebly reticulate. Eyes almost bare; head, pro- and meso-notum, and abdomen with sparse black hairs.

Body black in general with a slight blue reflection; mesopleurae with a slight purplish reflection; scutellum with a greenish reflection. Metanotum, propodeon and abdomen black. Wings hyaline, the veins pale brown. Legs black except the extreme base of all the femora, all the knees, apical two-thirds of all the tibiae and all the tarsi whitish yellow except the last joints which are brown; the remaining parts of legs black.

Length of body, 0.9 mm.; width of thorax, 0.32 mm.

Male—Antennae (Fig. 39) 0.77 mm. in length; scape subcylindrical; pedicel as long as wide at apex; funicle joints cylindrical, longer than wide, subequal in width; joints 1-3 subequal in length, and joints 4-6 slightly longer, subequal; first funicle joint twice as long as the pedicel.

Face with a greenish reflection except the part between the toruli which has a purplish reflection; mesoscutum with a slight bronze reflection; hind tarsi yellowish brown.

The other characters as in the female.

Length of body, 0.74 mm.; width of thorax, 0.35 mm.

Types in the author's collection.

A number of specimens were reared from the eggs of *Nesara antennata* SCOTT. at Nagasaki in November, 1924. This species is allied to *O. kuzanac* HOWARD, but differs from it as follows: ocelli in an obtuse-angled triangle; occipital margin acute; scutellum longitudinally strio-reticulate; antennal club of the female not broadly flattened.

### ***Psyllaephagus*** ASHMEAD

*Psyllaephagus* ASHMEAD, Proc. U. S. Nat. Mus., XXII (1900), p. 382; SCHMIEDF-KNECHT, Gen. Ins., XCVII (1909), p. 238; MERCLT, Fauna Ibérica, Encirt., 1921, p. 699.

***Psyllaephagus iwayaensis* sp. nov.**

(Figs. 40-43.)

Female—Head much wider than deep (39:32); frontovertex at the anterior ocellus as wide as one-third the width of the head; ocelli in an equi-lateral triangle, the posterior pair separated from the eye margins by one half their diameter and from the occipital margin by their diameter; scrobes rather shallow; mandibles (Fig. 40) with one upper broad cutting lobe and one lower tooth. Antennae (Fig. 41) 0.95 mm. in length; scape rather slender, slightly dilated below; pedicle twice as long as wide at apex, slightly longer than the first funicle joint; funicle joints gradually widening and lengthening distad; first four funicle joints longer than wide,

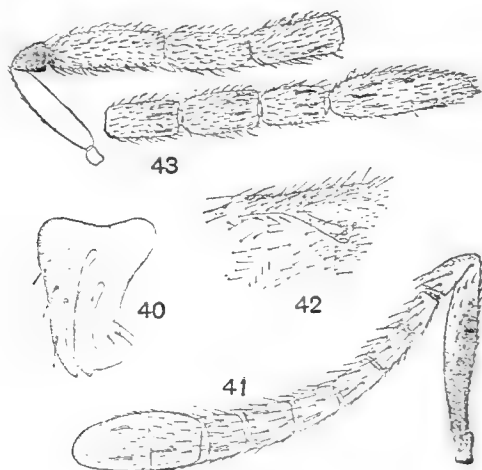
Fig. 40. *Psyllaephagus iwayaensis* sp. nov., mandible of female.

Fig. 41. Ditto, antenna of female.

Fig. 42. Ditto, veins of fore wing of female.

Fig. 43. Ditto, antenna of male.

the fifth joint as long as wide, and the sixth slightly wider than long; club slightly wider than the last funicle joint and slightly shorter than the last three funicle joints combined. Fore wings 1.58 mm. in length and 0.68 mm. in width, and uniformly ciliated except the basal part; submarginal, marginal, stigmal and postmarginal veins (Fig. 42) approximately in the ratio of 36:5:7:6; submarginal vein with about 13 bristles.

Hind wings uniformly ciliated except the basal part. Abdomen much shorter than the thorax; ovipositor hidden. Middle tibiae with about 6 spines on the tip.

Frontovertex more or less raised reticulate with sparse shallow punctures; face, cheeks, pro- and meso-notum minutely, scaly reticulate; mesopleurae longitudinally strio-reticulate; abdomen coarsely reticulate. Antennae yellowish brown, with sparse brown hairs, the basal half of the scape brown, and the tip of the club pale brown.

Head and body black in general with a slight purplish reflection. Head and mesonotum with a slight greenish reflection; metanotum, propodeon and abdomen black. Wings hyaline, the veins pale brown. Legs yellowish white. Middle and hind coxae, and hind femora except the tip black.

Length of body, 1.5 mm.; width of thorax, 0.57 mm.

Male—Head wider than deep (34:26); frontovertex at the anterior ocellus as wide as one half the width of the head; ocelli in an obtuse-angled triangle, the posterior pair separated from the eye margins and the occipital margin by their diameter; mandibles similar to those of the female. Antennae (Fig. 43) 1.2 mm. in length; scape rather slender; pedicle as long as wide at apex; funicle joints cylindrical, subequal in width; first funicle joint four times as long as pedicle, or as wide; joints 2-5 subequal in length, slightly shorter than the first and slightly longer than the last; club slightly narrower than the funicle, slightly shorter than the last two funicle joints combined. Fore wings 1.5 mm. in length and 0.63 mm. in width; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 30:5:7:5; submarginal vein with about 12 bristles. Middle tibiae with about 5 spines on the tip.

Color and sculpture almost similar to those of the female. Face and cheeks with a strong greenish reflection. Antennae yellowish brown, the pedicle and the apical half of the club brownish; funicle and club with brownish hairs.

Length of body, 1.3 mm.; width of thorax, 0.48 mm.

Types in the author's collection.

Numerous specimens were reared from a Psyllid found on *Cinnamomum* sp. at the foot of Mt. Iwaya near Nagasaki in June, 1925. This species is allied to *P. arbuticola* GAHAN and WATERSTON recorded from California.

### *Syrphophagus* ASHMEAD

*Syrphophagus* ASHMEAD, Proc. U. S. Nat. Mus., XXII (1900), p. 397; SCHMIEDENKNECHT, Gen. Ins., XCVII (1909), p. 250; MERCET, Fauna Ibérica, Encirt., 1921, p. 349.

### *Syrphophagus nigrocyaneus* ASHMEAD

*Syrphophagus nigrocyaneus* ASHMEAD, Journ. N. Y. Entom. Soc., XII (1904), p. 155.

This species is based upon the material collected by A. KOEBELE in Japan, but its locality is uncertain.

### *Microterys* THOMSON

*Microterys* THOMSON (part), Hym. Scand., IV (1875), p. 155; ASHMEAD, Proc. U. S. Nat. Mus., XXII (1900), p. 390.

*Encyrtus* MAVR, Verh. k. k. zool.-bot. Ges. Wien, XXV (1875), p. 702; SCHMIEDENKNECHT, Gen. Ins., XCVII (1909), p. 241; MERCET, Fauna Ibérica, Encirt., 1921, p. 389.

#### Key to the species

##### Female

- |  |        |                             |
|--|--------|-----------------------------|
| 1. Wings very small, degenerated   | ... .. | <i>degeneratus</i> sp. nov. |
| Wings normally developed   | ... .. | 2                           |
| 2. Fore wings with two pale fuscous bands  | ... .. | <i>clauseni</i> H. COMPÈRE  |
| Fore wings with three pale fuscous bands, the middle band narrow and twice interrupted | ... .. | 3                           |
| 3. Body almost entirely yellowish red-brown  | ... .. | 4                           |
| Body not entirely yellowish red-brown; abdomen brown or black                          | ... .. | 6                           |
| 4. First funicle joint longer than pedicel   | ... .. | <i>speciosus</i> ISHII      |
| First funicle joint not longer than pedicel  | ... .. | 5                           |
| 5. Last three funicle joints whitish   | ... .. | <i>flavus</i> HOWARD        |
| Last two funicle joints whitish yellow   | ... .. | <i>rufiflavus</i> sp. nov.  |
| 6. Mesonotum dark blue   | ... .. | 7                           |
| Mesonotum yellowish red-brown  | ... .. | 9                           |
| 7. Frontovortex dark blue with a purplish reflection                                   | ... .. | <i>interpunctus</i> (DALM.) |
| Frontovortex yellowish red-brown   | ... .. | 8                           |

- 8. Ocelli in an acute-angled triangle ... .. *obitsuensis* H. COMPERE
- Ocelli in an equi-lateral triangle ... .. *ericeri* ISHII
- 9. Fore wings with a small triangular hyaline spot on its outer margin near the apex  
of the wing ... .. *japonicus* ASHMEAD
- Fore wings without such a spot ... .. 10
- 10. Ovipositor slightly produced ... .. *kuwanai* sp. nov.
- Ovipositor long ... .. *caudatus* sp. nov.

**Male**

- 1. Mesopleurae yellowish ... .. *kuwanai* sp. nov.
- Mesopleurae yellowish red-brown or dark brown or black ... .. 2
- 2. Mesopleurae yellowish red-brown ... .. 3
- Mesopleurae dark brown or black ... .. 6
- 3. All the coxae pale yellow ... .. 4
- All the coxae not pale yellow ... .. 5
- 4. First funicle joint much longer than the second; hind tarsi pale brown.  
*speciosus* ISHII
- First funicle joint almost as long as the second; hind tarsi pale yellow except the  
last joint which is pale brown ... .. *flavus* HOWARD
- 5. Hind tibiae brown in the middle ... .. *obitsuensis* H. COMPERE
- Hind tibiae yellow ... .. *ericeri* ISHII
- 6. Marginal vein slightly longer than the postmarginal vein ... .. *interpunctus* (DALM.)
- Marginal vein shorter than the postmarginal vein ... .. *clauseni* H. COMPERE

**Microterys ericeri** ISHII

*Microterys ericeri* ISHII, Dept. Agr. & Comm. Japan, Imp. Plant Quar. Sta., Bull. 3 (1923), p. 109.

This species is parasitic of the male of *Ericerus pela* CHAV. found near Tôkyô and Nagasaki.

**Microterys flavus** (HOWARD)  
(Fig. 44.)

*Encyrtus flavus* HOWARD, Rep. U. S. Dept. Agr., 1880-81, p. 367.

*Microterys flavus* ASHMEAD, Proc. U. S. Nat. Mus., XXII (1900), p. 391.

This species is one of the important parasites of *Coccus hesperidum* L. in Japan and California. Male



Fig. 44.  
*Microterys flavus*  
(HOWARD), genitalia  
of male.

genitalia (Fig. 44) stout, with rather small lateral processes; claspers with one spine on the tip.

### ***Microterys interpunctus* (DALMAN)**

*Microterys interpunctus* MAYR, Verh. k. k. zool.-bot. Ges. Wien, XXV (1875), pp. 708 and 720; ASHMEAD, Proc. U. S. Nat. Mus., XXII (1900), p. 391.

Female—Head wider than deep (48:43); frontovertex at the anterior ocellus as wide as a little more than one-fifth the width of the head; ocelli in an acute-angled triangle, the posterior pair near the eye margins and separated from the occipital margin by a little more than their diameter; mandibles tridentate. Antennae 1.09 mm. in length; scape moderately dilated below, thrice as long as wide at the widest portion; pedicle twice as long as wide, slightly longer than the first funicle joint; funicle joints gradually shortening and widening distad, the first joint twice as long as wide, and the last joint slightly wider than long; club as long as the last three funicle joints combined. Fore wings 2.1 mm. in length and 0.9 mm. in width; cilia arranged in three bands, of which the middle band is distinctly interrupted twice; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 45:8:9:7; submarginal vein with about 23 bristles. Middle tibiae with about 10 spines on the tip.

Frontovertex with rather conspicuous punctures.

Scape and pedicle reddish brown with a touch of yellow; the upper part of pedicle and first four funicle joints brownish, and the last two funicle joints whitish; club black. Head yellowish red-brown except the frontovertex which is dark blue with a strong purplish reflection; pro- and meso-notum and metapleurae dark blue with a slight greenish reflection; tegulae and prepecti yellowish red-brown; mesopleurae, metanotum, propodeon and abdomen dark brown. Fore wings with three pale fuscous bands, the middle band interrupted twice, the veins pale brown. Hind wings hyaline. Fore legs yellowish red-brown; middle legs yellowish red except the coxae which are brownish; hind femora and tibiae deep red-brown, the tarsi yellowish, and the coxae black; all the last tarsal joints brownish.



Length of body, 1.95 mm.; width of thorax, 0.7 mm.

Male—Head wider than deep; frontovertex at the anterior ocellus as wide as a little more than one-third the width of the head; mandibles tridentate. Antennae 1.09 mm. in length; scape slightly dilated below; pedicle as long as wide, about one-third as long as the first funicle joint; funicle joints gradually decreasing in width distad, the first joint four times as long as wide, and the last joint twice as long as wide; club as long as the last two funicle joints combined. Fore wings 1.35 mm. long by 0.62 mm. wide, and uniformly ciliated except the basal third; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 31:5:6:5; submarginal vein with about 15 bristles. Middle tibiae with about 6 spines on the tip.

Head, pro- and meso-notum dark blue with a greenish reflection; tegulae yellowish brown; mesopleurae dark brown; metanotum, propodeon and abdomen black. Antennae pale brown except the pedicle which is whitish yellow; pedicle dark brown. Wings hyaline, the veins pale brown. Fore and middle legs whitish yellow except the middle coxae which are pale yellowish brown; hind legs brown without the tip and base of the tibiae, femora and tarsi which are yellowish.

Length of body, 1.35 mm.; width of thorax, 0.51 mm.

This species was reared from *Kermes natvae* KUW. collected at Ozuki, Kanagawa-ken, in May, 1923. It is of very wide distribution, being found in Europe and North America.

### **Microterys japonicus** ASHMEAD

*Microterys japonicus* ASHMEAD, Journ. N. Y. Entom. Soc., XII (1904), p. 155.

This species was collected by Y. NAWA at Gihu.

### **Microterys speciosus** ISHII

*Microterys speciosus* ISHII, Dept. Agr. & Comm. Japan, Imp. Plant Quar. Sta., Bull. 3 (1923), p. 70.

This species was reared from *Ceroplastes rubens* MASK. and *C. floridensis* COMST. collected near Nagasaki in May, 1926.

**Microterys clauseni** H. COMPERE

*Microterys clauseni* H. COMPERE, University of California Publications in Entomology, IV (1926), no. 2, p. 35.

This species is parasitic of *Ceroptastes floridensis* COMST., and was reared from it at Nagasaki in April, 1922.

**Microterys caudatus** sp. nov.

Female—Head wider than deep (30:28); frontovertex at the anterior ocellus as wide as a little more than one-fifth the width of the head; ocelli in rather an obtuse-angled triangle; mandibles tridentate. Antennae 0.69 mm. in length; scape moderately dilated below; pedicle twice as long as wide at apex, twice as long as the first funicle joint; funicle joints subequal in length and gradually widening distad, the first joint slightly longer than wide, and the last joint slightly wider than long; club a little longer than the last three funicle joints combined. Fore wings 1.3 mm. long by 0.53 mm. wide; cilia arranged in three bands, the middle band indistinctly interrupted twice; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 29:5:6:6; submarginal vein with about 17 bristles. Middle tibiae with about 6 spines on the tip. Ovipositor long, about three-fifths the length of the abdomen.

Head and thorax yellowish red-brown. Scape yellowish red-brown; pedicle and first four funicle joints yellowish brown, the last two funicle joints whitish yellow; club black. Fore wings with three pale fuscous bands, the middle band narrow and interrupted twice, the veins pale brown except the marginal vein which is brown.

Length of body, 1.2 mm.; width of thorax, 0.45 mm.

Male—Unknown.

Types in the author's collection.

This new species is based upon three specimens collected by sweeping near Nagasaki in October, 1924.

**Microterys degeneratus** sp. nov.

Female—Head wider than deep; frontovertex at the anterior ocellus

as wide as one-fifth the width of the head; ocelli in an acute-angled triangle, the posterior pair near the eye margins and separated from the occipital margin by twice their diameter; mandibles tridentate. Antennae 1 mm. in length; scape moderately dilated below; pedicle twice as long as wide at apex, slightly longer than the first funicle joint; funicle joints subequal in length, the first joint considerably longer than wide, and the last joint slightly wider than long; club slightly longer than the last three funicle joints combined. Fore wing extremely small, 0.23 mm. long by 0.12 mm. wide; hind wing entirely wanting. Middle tibiae with about 10 spines on the tip. Ovipositor slightly produced.

Antennae with scape orange yellow; pedicle and first four funicle joints yellowish red-brown, the third joint paler, and the last two funicle joints yellowish white; club black. Head and thorax yellowish red-brown; mesoscutum with a slight golden reflection; abdomen dark brown with metallic lustre. Fore wings hyaline. Legs yellowish red-brown.

Length of body, 1.35 mm.; width of thorax, 0.52 mm.

Type in the author's collection.

This new species is represented by a single specimen collected by sweeping at Amakusa, Kyûsyû, in August, 1923. It is allied to *M. brachypterus* MERCET, but may be distinguished from it by the wings which are much smaller.

### ***Microterys kuwanai* sp. nov.**

(Fig. 45.)

Female—Head wider than deep (40:35); frontovertex at the anterior ocellus as wide as a little less than one-sixth the width of the head; ocelli in an acute-angled triangle, the posterior pair near the eye margins and separated from the occipital margin by a little more than their diameter; mandibles tridentate. Antennae 1 mm. in length; scape moderately dilated below, about thrice as long as wide at the widest portion; pedicle twice as long as wide at apex, slightly longer than the first funicle joint; first three funicle joints a little longer than wide, and the remaining joints of the funicle slightly wider than long; club as long as the last three funicle

joints combined. Fore wings (Fig. 45) 1.7 mm. long by 0.72 mm. wide; cilia forming three bands, the middle band narrow and distinctly interrupted twice; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 40:9:9:7; submarginal vein with about 18 bristles. Middle tibiae with about 8 spines on the tip. Ovipositor slightly produced.

Scape yellowish red-brown; pedicle and first four funicle joints brown, the fourth joint usually paler; and the last two joints whitish; club black. Head, pro- and meso-notum and mesopleurae yellowish red-brown; meso-

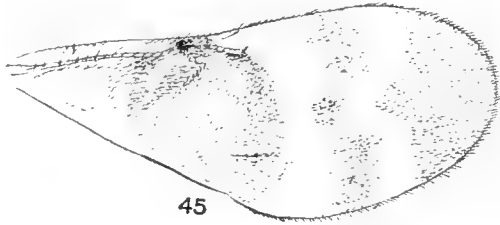


Fig. 45. *Microterys kuwanai* sp. nov., fore wing of female.

notum sometimes with a slight purplish reflection; metanotum, propodeon and abdomen brown. Fore wings with three pale fuscous bands, the middle band narrow and distinctly interrupted twice, the veins pale brown except the postmarginal vein which is yellowish white. Legs yellowish red-brown, the middle tarsi paler; all the last tarsal joints brown.

Length of body, 1.65 mm.; width of thorax, 0.6 mm.

Male—Head wider than deep; frontovertex at the anterior ocellus as wide as a little less than one-fourth the width of the head; ocelli in an obtuse-angled triangle; mandibles tridentate. Antennae 0.89 mm. in length; scape considerably dilated below; pedicle slightly wider than long; funicle joints gradually shortening distad, the first funicle joint a little more than twice as long as wide; club almost as long as the last two funicle joints combined. Fore wings 1 mm. long by 0.53 mm. wide, and uniformly ciliated except the basal third; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 28:3:6:2; submarginal vein with about 14 bristles. Middle tibiae with about 4 spines

on the tip.

Scape yellow; pedicle brown above, paler below; funicle joints and club pale brown, the first funicle joint deeper on the upper margin. Head, pro- and meso-notum dark blue with a greenish reflection; mesopleurae and tegulae yellowish; metanotum, propodeon and abdomen brownish black. Wings hyaline, the veins pale brown. Fore coxae, middle legs and hind tarsi whitish yellow; hind coxae, all the last tarsal joints and middle part of the hind tibiae pale brown; the remaining parts of legs yellow.

Length of body, 1.26 mm.; width of thorax, 0.42 mm.

Types in the author's collection.

A number of this species were reared from *Pulvinaria horii* KUW. on *Quercus glauca* in June, 1922, at Nagasaki, from *Pulvinaria camericola* SIGN. on *Ilex otherea* in June, 1923, at Ozuki, Kanagawa-ken, from *Lecaniodiaspis quercus* on *Quercus glauca* in April, 1924, at Nagasaki, and from *Coccus hesperidum* L. on the citrus tree in June, 1924, at Nagasaki.

### **Microterys okitsuensis** H. COMPERE

*Microterys okitsuensis* H. COMPERE, University of California Publications in Entomology IV (1926), no. 2, p. 38.

Male—Head wider than deep (27:23); frontovertex at the anterior ocellus as wide as a little more than one-fourth the width of the head; ocelli in an obtuse-angled triangle; mandibles tridentate. Antennae 0.74 mm. in length; scape subcylindrical; pedicle slightly wider than long; funicle joints subequal in width and gradually decreasing in length distad, the first joint four times as long as wide; club as long as the last two funicle joints combined. Fore wings 1.02 mm. in length and 0.48 mm. in width, and uniformly ciliated except the basal third; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 22:3:6:3; submarginal vein with about 13 bristles. Middle tibiae with about 5 spines on the tip.

Head, pro- and meso-notum dark blue with a greenish reflection; tegulae pale yellowish brown; mesopleurae brown, paler towards below; metanotum, propodeon and abdomen black. Scape yellow; pedicle brown;

funicle joints and club brown. Wings hyaline, the veins pale brown. Fore and middle legs whitish yellow except the middle coxae which are pale brown; hind legs pale yellow except the middle part of the femora and tibiae which are pale brown.

Length of body, 1.05 mm.; width of thorax, 0.31 mm.

Types in the author's collection.

A number of this species were reared at Nagasaki from *Pulvinaria aurantii* CKLL. on the citrus tree in June, 1923 and from *P. psidii* MASK. on *Pittosporum tobira* in August, 1923.

### ***Microterys rufofulvus* sp. nov.**

Female—Head wider than deep (36:32); frontovertex at the anterior ocellus as wide as one-sixth the width of the head; ocelli in an acute-angled triangle, the posterior pair near the eye margins and separated from the occipital margin by a little more than their diameter; mandibles tridentate. Antennae 0.96 mm. in length; scape moderately dilated below; pedicle twice as long as wide at apex, slightly longer than the first funicle joint; funicle joints slightly shortening and widening distad, the first joint a little longer than wide, and the last joint slightly wider than long; club as long as the last three funicle joints combined. Fore wings 1.65 mm. long by 6.3 mm. wide; cilia arranged in three bands, the middle one narrow and not distinctly interrupted; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 37:6:7:5; submarginal vein with about 20 bristles. Ovipositor slightly produced. Middle tibiae with about 8 spines on the tip.

Scape, pedicle and first four funicle joints yellowish red-brown, the upper margin of the pedicle and of the first three funicle joints dark brown; last two funicle joints white; club black. Body yellowish red-brown exclusive of the metanotum and propodeon brown. Fore wings with three pale fuscous bands of which the middle one is narrow, interrupted twice, and connected medially with the outer one; veins pale yellowish brown, the marginal vein brown. Legs yellowish red-brown except the tarsi which are yellowish white.

Length of body, 1.58 mm.; width of thorax, 0.54 mm.

Male—Unknown.

Types in the author's collection.

Two specimens of this new species were collected by sweeping at Isahaya, Nagasaki-ken, in August, 1923.

***Plesiomicroterys*** gen. nov.

This new genus is allied to *Microterys* DALMAN, but differs from it in the following points: funicle joints more transverse; wings very large and densely ciliated, the stigmal vein forming with the postmarginal a much larger angle, the submarginal vein more or less expanded in the apical fourth; the submarginal cell of the hind wings considerably broader; propodeon with a carina on each side; middle tibiae without a spine on the tip.

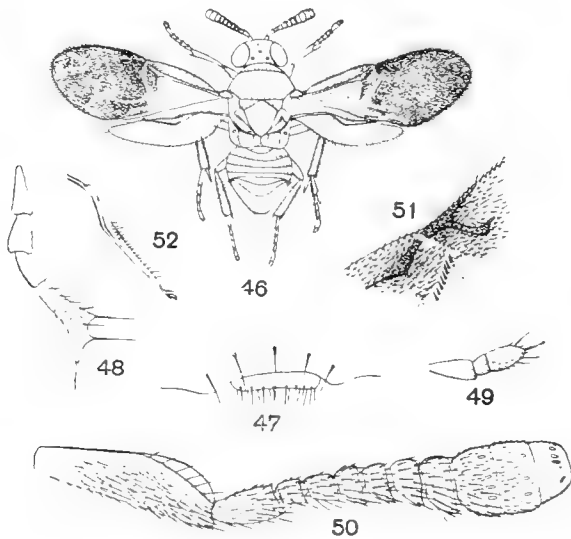
Genotype: *Plesiomicroterys infuscatus* sp. nov.

***Plesiomicroterys infuscatus*** sp. nov.

(Figs. 46-52.)

Female (Fig. 46)—Head wider than deep (44:37); frontovertex at the anterior ocellus as wide as one-third the width of the head; scrobes moderately deep, round and reaching the middle of the face; cheeks moderately long; toruli separated from each other by one-fourth the width of the head and separated from the clypeal edge by their length; mandibles tridentate. Antennae (Fig. 50) 0.78 mm. in length; scape considerably dilated below, as long as the pedicel and the first three funicle joints combined; pedicel twice as long as wide at apex, as long as the first two funicle joints combined; funicle joints subequal in length, gradually widening distad so that the last joint is twice as wide as long, the first joint slightly longer than wide, and the second as long as wide; club slightly wider than the last funicle joint, as long as the last four funicle joints combined. Fore wings 2.1 mm. long by 0.9 mm. wide; and densely ciliated in the apical two-thirds; submarginal, marginal, stigmal and postmarginal veins (Fig. 51) approximately in the ratio of 45:8:11:8; sub-

marginal vein with about 41 bristles. Hind wings 1.43 mm. in length and 0.47 mm. in width, and rather densely ciliated except the extreme base; submarginal cell considerably broad with a row of about 22 cilia. Thorax a little wider than the head; abdomen slightly shorter than the thorax; ovipositor hidden; propodeon with a carina on each side. Middle tibiae wholly devoid of spines on the tip; hind tibiae with two unequal spurs on the tip. Maxillary palpus, labial palpus, and labrum as in Figs. 47-49.



- Fig. 46. *Flesiomicrotorys infuscatus* sp. nov., female.  
 Fig. 47. Ditto, labrum of female.  
 Fig. 48. Ditto, maxillary palpus of female.  
 Fig. 49. Ditto, labial palpus of female.  
 Fig. 50. Ditto, antenna of female.  
 Fig. 51. Ditto, veins of fore wing of female.  
 Fig. 52. Ditto, veins of hind wing of female.

Head, pro- and meso-notum uniformly, minutely reticulate except the cheeks which are minutely, scaly reticulate; frontovortex with sparse, shallow punctures; mesopleurae minutely reticulate; abdomen coarsely reticulate. Eyes sparsely pubescent; clypeal margin with four bristles; head, pro- and meso-notum and abdomen with sparse brown hairs.

Antennae dark brown, the scape and pedicel black. Body black in



general; head, pro- and meso-notum and tegulae dark blue with a slight greenish reflection. Fore wings infuscated except the basal part, the veins brown. Hind wings hyaline, the veins brown. Legs black in general. Fore tarsi, spur and tip of middle tibiae yellowish brown; middle and hind tarsi whitish yellow except the last joint of the hind tarsi which is brown.

Length of body, 1.8 mm.; width of thorax, 0.72 mm.

Male—Unknown.

Types in the author's collection.

Numerous specimens were collected by sweeping near Nagasaki in June, 1922.

### *Tyndarichus* HOWARD

*Tyndarichus* HOWARD, U. S. Dept. Agr. Bur. Ent., Techn. Ser., No. 19 (1910), pt. 1, p. 5; MERCET, Fauna Ibérica, Encirt., 1921, p. 652.

### *Tyndarichus navae* HOWARD

*Tyndarichus navae* HOWARD, U. S. Dept. Agr. Bur. Ent., Techn. Ser., No. 19 (1910), pt. 1, p. 5.

This species was first reared from eggs of *Portheiria dispar* L., which were sent to America from Japan by U. NAWA. A considerable number of dissections made by Messrs. FISKE and SMITH indicate that it is invariably a secondary parasite, its host being usually *Shedius*, occasionally *Pachyneuron*, and possibly *Anastatus*.

### *Phaenodiscus* FÖRSTER

*Phaenodiscus* FÖRSTER, Hym. Stud., II (1856), p. 144; MAYR, Verh. k. k. zool.-bot. Ges. Wien., XXV (1875), p. 757; THOMSON, Hym. Scand., IV (1875), p. 136; ASHMEAD, Proc. U. S. Nat. Mus., XXII (1900), p. 376; SCHMIEDEKNECHT, Gen. Ins., XCVII (1909), p. 233; MERCET, Fauna Ibérica, Encirt., 1921, p. 613.

### *Phaenodiscus eriococci* sp. nov.

(Figs. 53 and 54.)

Female—Head a little wider than deep (40:37); frontovertex at the anterior ocellus as wide as one-fifth the width of the head; ocelli in an

acute-angled triangle, the posterior pair almost touching the eye margins and separated from the occipital margin by a little more than their diameter; scrobes very shallow; mandibles tridentate. Antennae (Fig. 54) 0.9 mm. in length; scape slender and long; pedicle twice as long as wide

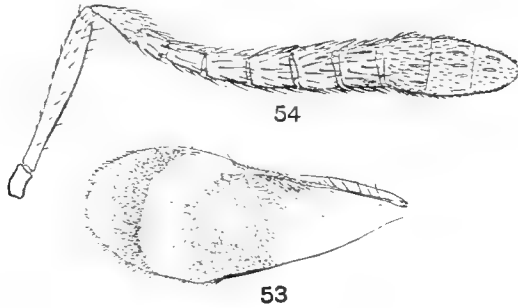


Fig. 53. *Phaenodiscus eriococci* sp. nov., fore wing of female.

Fig. 54. Ditto, antenna of female.

at apex, much longer than the first funicle joint; funicle joints subequal in length except the first joint which is slightly shorter, and gradually widening distad, the first joint twice as long as wide and the last joint as long as wide; club as long as the last three funicle joints combined. Fore wings (Fig. 53) 1.17 mm. long by 0.51 mm. wide; cilia arranged in two bands; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 28:7:6:4; submarginal vein with about 15 bristles. Hind wings uniformly ciliated. Axillae slightly separated; abdomen a little shorter than the thorax; ovipositor slightly produced.

Head minutely, scaly reticulate, with large punctures in sparse numbers; pronotum and mesoscutum minutely raised reticulate; mesopleurae minutely reticulate; abdomen coarsely reticulate. Eyes sparsely, finely pubescent; mesoscutum with whitish hairs; metapleurae with thick, long white hairs.

Antennae with scape yellowish; pedicel yellowish brown; funicle and club dark brown with rather close black hairs. Body black with a slight blue reflection. Face with a blue reflection; pro- and meso-notum with a strong purplish blue reflection; mesopleurae, matanotum and propodeon black; abdomen black with a greenish reflection. Fore wings with two

pale fuscous bands, the veins pale brown. Hind wings hyaline. Legs yellowish in general. The basal two-thirds of all the femora dark brown; the base of middle tibiae brown; spur of middle tibiae and middle tarsi whitish yellow; all the coxae black; the tip of all the tarsi brown.

Length of body, 1.32 mm.; width of thorax, 0.53 mm.

Male—Similar to the female without the following differences. Antennae 1.2 mm. in length; scape slender; pedicle as wide as long; funicle joints cylindrical, much longer than wide and decreasing in length distad; the first funicle joint five times as long as wide and the last joint three times as long as wide; club slightly less than twice the length of the last funicle joint. Scape yellowish brown; flagellum brown with sparse, short brown hairs. Wings hyaline, the veins pale brown.

Length of body, 1.28 mm.

Types in the author's collection.

This new species was reared from *Eriococcus lagerstraeimiae* Kuw. obtained near Nagasaki in September, 1921, and from *E. onukii* Kuw. collected at Ozuki, Kanagawa-ken, in August, 1925.

### *Cheiloneurus* WESTWOOD

*Cheiloneurus* FÖRSTER, Hym. Stud., II (1856), p. 32; MAYR, Verh. k. k. zool.-bot. Ges. Wien, XXV (1875), p. 743; THOMSON, Hym. Scand., IV (1875), p. 147; ASHMEAD, Proc. U.S. Nat. Mus., XXII (1900), p. 400; SCHMIDFCKNECHT, Gen. Ins., XCVII (1909), p. 252; WALKER, Notes on Chalcidae, pt. 4 (1871), p. 69; MERCET, Fauna Ibérica, Encirt., 1921, p. 637.

*Sterrhocoma* FÖRSTER, Hym. Stud., II (1856), p. 37.

#### Key to the species

##### Female

1. Body black with a blue reflection; club very large and as long as the funicle; ovipositor long ... .. *nagasakiensis* sp. nov.  
Head and thorax reddish yellow in general; abdomen black with a metallic reflection; club not especially large ... .. 2
2. Fore wings with the apical two-thirds fuscous ... .. *japonicus* ASHMEAD  
Fore wings with the apical two-thirds fuscous except the outer margin ... 3
3. Funicle joints entirely white ... .. 4  
Funicle joints white except the last joint which is brown ... .. *ceroplastis* ISHII
4. Club as long as the last three funicle joints combined ... .. *tenicornis* sp. nov.  
Club as long as the last four funicle joints combined ... .. *kanagawaensis* sp. nov.

**Cheiloneurus ceroplastis** ISHII

*Cheiloneurus ceroplastis* ISHII, Dept. Agr. & Comm. Japan, Imp. Plant Quar. Sta., Bull. 3 (1923), p. 104.

This species is parasitic of *Ceroplastes rubens* MASK. and *C. ceriferus* AND. found near Nagasaki.

**Cheiloneurus japonicus** ASHMEAD

*Cheiloneurus japonicus* ASHMEAD, Journ. N. Y. Entom. Soc., XII (1904), p. 156.

This species was collected by Y. NAWA at Gihu.

**Cheiloneurus kanagawaensis** sp. nov.

Female—Head almost as wide as deep; frontovertex at the anterior ocellus as wide as one-sixth the width of the head; ocelli in an acute-angled triangle, the posterior pair close to the eye margins and separated from the occipital margin by a little more than their diameter; mandibles with one upper broad cutting ridge and one lower tooth. Antennae 1 mm. in length; scape moderately dilated below; pedicle twice as long as wide at apex and slightly longer than the first funicle joint; funicle joints longer than wide, subequal in length and slightly widening distad; first funicle joint slightly less than twice as long as wide; club considerably wider than the last funicle joint and about as long as the last four funicle joints combined. Fore wings 1.43 mm. long by 0.56 mm. wide, and uniformly ciliated except the basal third; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 29:11:4:2; submarginal vein with about 13 bristles. Abdomen almost as long as the thorax; ovipositor about one-seventh the length of the abdomen.

Head, pronotum and mesoscutum minutely reticulate; frontovertex, axillae and scutellum minutely raised reticulate; abdomen coarsely reticulate.

Head dark yellowish red-brown; frontovertex deep brown with a slight greenish reflection; cheeks with a slight purplish reflection. Scape dark yellowish red-brown with the base and upper margin brown, and with the tip whitish; pedicle dark brown with the apical half white; funicle joints

whitish yellow; club black. Pronotum, mesoscutum and scutellum black with a slight greenish blue reflection; axillae, tegulae and mesopleurae dark yellowish red-brown; mesopleurae with a slight purplish reflection; metanotum and propodeon brown; mesoscutum with sparse whitish hairs; scutellum with a tuft of black bristles near the tip; abdomen black with a violet reflection, especially in the basal part. Fore wing fuscous except the basal third and outer margin. Hind wings hyaline. Fore legs yellowish red-brown except the apical half of the femora and basal two-thirds of the tibiae which are brown; the apical two-thirds of middle and hind femora, and the basal two-thirds of middle and hind tibiae dark brown; the remaining parts of middle and hind legs whitish yellow; the apex of all the legs brown.

Length of body, 1.5 mm.; width of thorax, 0.45 mm.

Male—Unknown.

Types in the author's collection.

This new species was based upon five specimens collected by sweeping at Ozuki, Kanagawa-ken, in June, 1922.

***Cheiloneurus nagasakiensis* sp. nov.**

(Figs. 55 and 56.)

Female—Head deeper than wide (33:28); frontovertex at the anterior ocellus as wide as one-ninth the width of the head; eye margins slightly converging anteriorly; ocelli in an acute-angled triangle, the posterior pair close to the eye margins and separated from the occipital margin by twice their diameter; mandibles similar to those of *C. kanagawaensis*. Antennae (Fig. 55) 0.86 mm. in length; scape slender and cylindrical; pedicel twice as long as wide at apex and as long as the first two funicle joints combined; funicle joints wider than long except the first which is as long as wide, and increasing in width distad; funicle joints 2-4 subequal in length, the first and last two joints slightly longer; club very large, much wider than the last funicle joint and as long as the funicle. Fore wings (Fig. 56) 1.13 mm. long by 0.42 mm. wide, and uniformly ciliated except the basal part; submarginal, marginal, stigmal and postmarginal veins approx-

imately in the ratio of 21:11:3:2; submarginal vein with about 11 bristles. Abdomen slightly shorter than the thorax; ovipositor long, about

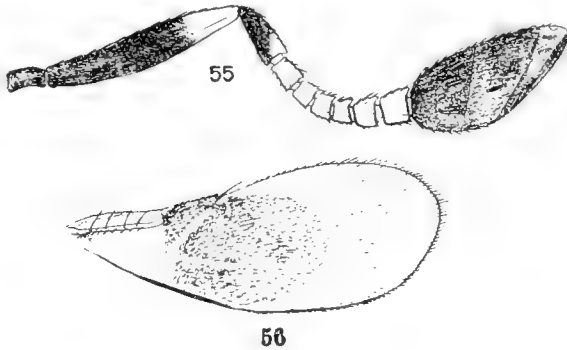


Fig. 55. *Cheiloneris nagasakiensis* sp. nov., antenna of female.

Fig. 56. Ditto, fore wing of female.

three-fifths the length of the abdomen. Middle tibiae with about 8 spines on the tip.

Head, axillae and scutellum minutely reticulate; pronotum and mesoscutum scaly reticulate; mesopleurae longitudinally strio-reticulate; propodeon smooth; abdomen coarsely reticulate. Mesoscutum with sparse whitish hairs; scutellum with a tuft of black bristles near the tip.

Body black with a blue reflection. Scape brownish black with the tip white; pedicel brownish black with the tip paler; funicle joints white; club black. Fore wings infuscated except the basal third and broad outer margin, the veins brown except the submarginal which is hyaline. Hind wings hyaline. Fore legs dark brown, the tarsi pale brown; the basal third and tip of femora, apical third of tibiae, spur and tarsi of middle legs whitish yellow, the remaining parts of the middle legs dark brown; hind legs dark brown except the tip of the tibiae and tarsi whitish yellow; the last joint of all the tarsi pale brown.

Length of body, 1.2 mm.; width of thorax, 0.45 mm.

Male—Unknown.

Types in the author's collection.

This new species is one of the most important parasites of the mealy

bug in the vicinity of Nagasaki. It was reared from *Pseudaococcus* sp. found on the citrus tree in some months from April to September.

***Cheiloneurus tenuicornis* sp. nov.**

(Fig. 57.)

Female—Head almost as wide as deep; frontovortex at the anterior ocellus as wide as one-seventh the width of the head; ocelli in an acute-angled triangle, the posterior pair close to the eye margins and separated from the occipital margin by twice their diameter; mandibles similar to those of *C. kanagawaensis*. Antennae (Fig. 57) 1 mm. in length; scape slightly dilated below; pedicle twice as long as wide at apex and as long as the first funicle joint; funicle joints longer than wide, subequal in length and slightly widening distad; first funicle joint twice as long as wide; club slightly wider than the last funicle joint and about as long as the last three funicle joints combined. Fore wings 1.35 mm. long by 0.53 mm. wide, and uniformly ciliated except the basal third; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 28 : 12 : 4 : 3; submarginal vein with about 17 bristles. Abdomen as long as the thorax; ovipositor about one-fourth the length of the abdomen.

Sculpture similar to that of *C. kanagawaensis*.

Head yellowish red-brown, the frontovortex dark brown; pronotum and mesoscutum black with a slight blue reflection and with sparse whitish hairs; axillae, tegulae, mesopleurae and propodeon dark yellowish red-brown; scutellum brownish black with a tuft of black bristles near the tip; metanotum brown. Scape yellowish red-brown, the tip whitish; pedicle dark brown, the apical half whitish; funicle joints whitish, yellowish towards the last joint; club black. Abdomen black with a violet reflection; ovipositor whitish yellow. Fore wings infuscated except the basal third and narrow outer margin, the veins brown except the submarginal

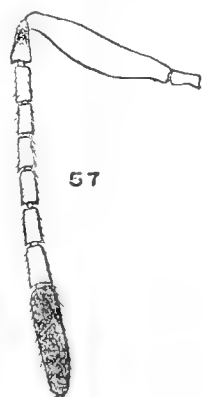


Fig. 57  
*Cheiloneurus tenuicornis*  
sp. nov., antenna of  
female.

which is hyaline. Hind wings hyaline. Fore and hind coxae, basal half of fore femora, middle femora except the apical fourth, spur and apical half of middle tibiae, middle tarsi, apical half of hind tibiae and hind tarsi whitish yellow; the basal half of fore tibiae, apical fourth of middle femora, basal half of middle tibiae and hind tibiae brown; the remaining parts of legs pale yellowish red.

Length of body, 1.65 mm. and width of thorax, 0.57 mm.

Male—Unknown.

Types in the author's collection.

This new species was reared from *Kermes miyasakii* KUWANA found on *Quercus glandulifera* at Ozuki, Kanagawa-ken, in June, 1922. It is closely allied to *C. quercus* MAYR recorded from Europe.

### *Anabrolepis* TIMBERLAKE

*Anabrolepis* TIMBERLAKE, Proc. Haw. Entom. Soc., IV (1920), no. 2, p. 431.

#### Key to the species

##### Female

1. Fore wings with four transverse fuscous bands connected by a median longitudinal band except the basal band.  
 Last funicle joint yellowish; first three funicle joints moniliform; club slightly longer than the funicle ... .. *extranea* TIMBERLAKE  
 Last three funicle joints yellowish; first three funicle joints not moniliform; club as long as the last five funicle joints combined ... .. *japonica* ISHII
2. Fore wings with two transverse fuscous bands connected medially; last funicle joint yellowish ... .. *bifasciata* ISHII

### *Anabrolepis bifasciata* ISHII

*Anabrolepis bifasciata* ISHII, Dept. Agr. & Comm. Japan, Imp. Plant Quar. Sta., Bull. 3 (1923), p. 106.

This species was collected by sweeping at Nagasaki, and its host is unknown.

### *Anabrolepis extranea* TIMBERLAKE

*Anabrolepis extranea* TIMBERLAKE, Proc. Haw. Entom. Soc., IV (1920), no. 2 p. 434.



Many specimens of this species were collected by sweeping at Ozuki, Kanagawa-ken, in June, 1923, and at Isahaya, Nagasaki-ken in August, 1924. Mr. A. SAWADA reared this species from *Pseudaonidia paeoniae* CKLL. found on the tea plant at Isahaya in June, 1926. This species is known to occur in Hawaii.

### **Anabrolepis japonica** ISHII

*Anabrolepis japonica* ISHII, Dept. Agr. & Comm. Japan, Imp. Plant Quar. Sta., Bull. 3 (1923), p. 104.

This species was reared from *Aspidiotus bambusarum* CKLL. at Nagasaki in May, 1926.

### **Pareusemion** ISHII

*Pareusemion* ISHII, Dept. Finance, Japan, Imp. Plant Quar. Serv., Tech. Bull. 3 (1925), p. 21.

### **Pareusemion studiosum** ISHII

*Pareusemion studiosum* ISHII, Dept. Finance, Japan, Imp. Plant Quar. Serv., Tech. Bull. 3 (1925), p. 23.

This species is one of the most important parasites of *Coccus hesperidum* L. in the vicinity of Nagasaki.

### **Anicetus** HOWARD

*Anicetus* HOWARD, Proc. U. S. Nat. Mus., XVIII (1896), p. 639; ASHMEAD, Proc. U. S. Nat. Mus., XXII (1900), p. 405.

### **Anicetus annulatus** TIMBERLAKE

*Anicetus annulatus* TIMBERLAKE, Proc. Haw. Entom. Soc., IV (1919), no. 1, p. 227.

This species was reared by H. COMPERE from *Coccus hesperidum* L. and *C. pseudomagnoliarum* (KUW.) forwarded to him by C. P. CLAUSEN at Yokohama, and by P. H. TIMBERLAKE from *Coccus hesperidum* L. in California and also from the tessellated palm scale, *Eucalymnatus tessellatus* SIG. in Hawaii. The writer was also able to rear it from *Pulvinaria* sp. on *Pittosporum tobira* in May, 1923, and from *Coccus hesperidum* in July, 1924, at Nagasaki.

**Anicetus ceroplastis** sp. nov.

Female—Head much wider than deep (46; 31); frontovertex at the anterior ocellus as wide as a little more than one-eighth the width of the head; ocelli in an acute-angled triangle, the posterior pair close to the eye margins and separated from the occipital margin by one half their diameter; mandibles tridentate. Antennae 1.08 mm. in length; scape much dilated below and as long as wide at the widest portion; pedicle wider than long; club as long as the funicle and pedicle combined. Fore wings 1.65 mm. long by 0.72 mm. wide, and uniformly ciliated except the basal third; submarginal vein with about 15 bristles. Hind wings uniformly ciliated except the basal part. Abdomen much shorter than the thorax; ovipositor long, about one half the length of the abdomen. Middle tibiae with about 12 spines on the tip.

Sculpture similar to that of *A. annulatus* TIMB.

Body yellowish red-brown in general; metanotum and basal part of abdomen brownish; frontovertex, mesoscutum, metapleurae and basal part of abdomen with a purplish reflection. Face and cheeks with a transverse black band crossing their middle. Antennae yellowish red-brown; lower margin of scape and upper margin and apical part of club brown. Fore wings infuscated as in *A. annulatus* TIMB. Hind wings hyaline with a pale fuscous dot near the anterior margin. Legs yellowish red-brown in general. Middle legs whitish yellow except the tibiae; hind tibiae with two brownish annuli; first joint of hind tarsi black, the last joint of the same brown, and hind tarsal joints 2-4 whitish.

Length of body, 1.8 mm.; width of thorax, 0.68 mm.

Male—Unknown.

Types in the author's collection.

**Cerafterocerus** WESTWOOD

*Cerafterocerus* MAYR, Verh. k. k. zool.-bot. Ges. Wien, XXV (1875), p. 747; THOMSON, Hym. Scand., IV (1875), p. 150; ASHMEAD, Proc. U. S. Nat. Mus., XXII (1900), p. 403; SCHMIEDERNECHT, Gen. Ins., XCVII (1903), p. 254; MERCET, Fauna Ibérica, Encirt., 1921, p. 659.

*Telegraphus* RATZBURG, Ich. d. Forstins., II (1848), p. 152.

***Cerapterocerus mirabilis* WESTWOOD**

*Cerapterocerus mirabilis* MAYR, Verh. k. k. zool.-bot. Ges. Wien, XXV (1875), p. 748; SILVESTRI, Boll. Lab. Zool. Gen. Agr. Portici, XIII (1919), p. 104; MICRET, Fauna Ibérica, Encirt., 1921, p. 661.

*Telegraphus maculipennis* RATZBURG, Ich. d. Forstins., II (1848), p. 153.

*Cerapterocerus mirabilicornis* THOMSON, Hym. Scand., IV (1875), p. 151.

A single female was collected by sweeping in the vicinity of Tôkyô in July, 1927.

***Metacerapterocerus* gen. nov.**

This genus differs from *Cerapterocerus* in the following points: fore wings not so elongate; marginal vein short; postmarginal vein present, almost as long as the stigmal vein; submarginal vein without a triangular expansion at the apical third.

Genotype: *Cerapterocerus fortunatus* ISHII.

***Metacerapterocerus fortunatus* (ISHII)**

*Cerapterocerus fortunatus* ISHII, Dept. Finance, Japan, Imp. Plant Quar. Serv., Tech. Bull. 3 (1925), p. 26.

This species was reared at Nagasaki from *Thoracaphis* sp. on *Quercus glauca*, probably hyperparasitic on *Aphidencyrtoides thoracaphis*.

***Metacerapterocerus similis* (ISHII)**

*Cerapterocerus similis* ISHII, Dept. Finance, Japan, Imp. Plant Quar. Serv., Tech. Bull. 3 (1925), p. 27.

This species was collected by sweeping at Nagasaki.

***Cerapteroceroides* ASHMEAD**

*Cerapteroceroides* ASHMEAD, Journ. N. Y. Entom. Soc., XII (1904), p. 156.

***Cerapteroceroides japonicus* ASHMEAD**

*Cerapteroceroides japonicus* ASHMEAD, Journ. N. Y. Entom. Soc., XII (1904), p. 156.

This interesting species was collected by A. KOEBELE at Atami and by Y. Nawa at Gihu.

***Comperiella*** HOWARD

*Comperiella* HOWARD, Ent. News, XVII (1906), p. 121; Ibid., XVIII (1907), p. 237.  
*Habrolepista* MERCET, Fauna Ibérica, Encirt., 1921, p. 668.

***Comperiella bifasciata*** HOWARD

*Comperiella bifasciata* HOWARD, Ent. News, XVII (1906), p. 122 (♀); Ibid., XVIII (1907), p. 237 (♂).

This species was originally described from China. It is one of the important parasites of *Chrysomphalus aurantii* MASK. and *C. aonidum* (L.) in southern parts of Japan, such as Sizuoka, Kôbe, Mozi, Kumamoto, Kagosima and Nagasaki.

***Comperiella unifasciata*** ISHII

*Comperiella unifasciata* ISHII, Dept. Finance, Japan, Imp. Plant Quar. Serv., Tech. Bull. 3 (1925), p. 25.

This species is parasitic of *Pscudaonidia duplex* (CKLL.) in the vicinity of Nagasaki.

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## Host relations of the species described in this paper

Parasites	Hosts
<i>Aenasioidea tenuicornis</i> TIMB.	<i>Kermes miyasakii</i> KUW.
<i>Anabrolepis extranea</i> TIMB.	<i>Pseudaonidia paconiae</i> CKLL.
<i>Anabrolepis japonica</i> ISHII	<i>Aspidiotus bambusarum</i> CKLL.
<i>Anagyrus alboclavatus</i> sp. nov.	<i>Pseudococcus</i> sp. on <i>Ficus erecta</i>
<i>Anagyrus antoninae</i> TIMB.	<i>Antonina craxi</i> CKLL.
<i>Anagyrus flavus</i> sp. nov.	<i>Pulvinaria</i> sp. on <i>Mallotus japonicus</i>
<i>Anagyrus sawadai</i> sp. nov.	<i>Eriococcus</i> sp. on <i>Cryptomeria japonica</i> .
<i>Anagyrus subalbipes</i> sp. nov.	<i>Pseudococcus</i> sp. on citrus tree
<i>Anicetus annulatus</i> TIMB.	{ <i>Coccus hesperidum</i> L.
	{ <i>Coccus pseudomagnoliarum</i> (KUW.)
	{ <i>Eucalymnatus tessellatus</i> SIG.
	{ <i>Pulvinaria</i> sp. on <i>Pittosporum tobira</i>
<i>Anicetus ceroplastis</i> sp. nov.	<i>Ceroplastes ceriferus</i> AND.
<i>Anisotylus albifrons</i> ISHII	<i>Scymnus</i> sp.
<i>Aphidencyrtoides thoracaphis</i> sp. nov.	<i>Thoracaphis</i> sp. on <i>Quercus glauca</i>
<i>Aphycus albicornis</i> TIMB.	<i>Pulvinaria</i> sp.
<i>Aphycus albopleuralis</i> ASHMEAD	<i>Kermes</i> sp. on cherry tree
<i>Aphycus orientalis</i> H. COMPERE	{ <i>Coccus hesperidum</i> L.
	{ <i>Coccus pseudomagnoliarum</i> (KUW.)
<i>Aphycus pulvinariae</i> HOWARD	{ <i>Coccus hesperidum</i> L.
	{ <i>Eulecanium</i> sp. on <i>Euonymus europaea</i>
	{ <i>paea</i> and <i>Vitis vinifera</i>
<i>Aphycus timberlakei</i> ISHII	<i>Eulecanium</i> sp. on <i>Euonymus europaea</i>
<i>Astymachus japonicus</i> HOWARD	<i>Aclerda japonica</i> NEWSTEAD
<i>Blastothrix kernivora</i> sp. nov.	{ <i>Kermes miyasakii</i> KUW.
	{ <i>Kermes natvae</i> KUW.
<i>Cheiloncurnus ceroplastis</i> ISHII	{ <i>Ceroplastes ceriferus</i> AND.
	{ <i>Ceroplastes rubens</i> MASK.
<i>Cheiloncurnus nagasakiensis</i> sp. nov.	<i>Pseudococcus</i> sp. on citrus tree

## Parasites

*Cheiloncurus tenuicornis* sp. nov.*Clausenia purpurca* ISHII*Compericlla bifasciata* HOWARD*Compericlla unifasciata* ISHII*Copidosoma komabae* (ISHII)*Cynipencyrtus flavus* sp. nov.*Encyrtus barbatus* TIMB.*Encyrtus sasakii* sp. nov.*Homalotylus flaminius* (DALM.)*Isodromus axillaris* TIMB.*Leptomastix citri* sp. nov.*Metacraepitercerus fortunatus* (ISHII)*Microterys clauseni* H. COMPERE*Microterys ericeri* ISHII*Microterys flavus* (HOWARD)*Microterys interpunctus* (DALM.)*Microterys kuzwanai* sp. nov.*Microterys okitsucensis* H. COMPERE*Microterys speciosus* ISHII*Ooencyrtus* (*Ooencyrtus*) *uzarae* sp. nov.*Ooencyrtus* (*Schedius*) *kuzwanae* (HOWARD)

## Hosts

*Kermes miyasakii* KUW.*Pseudococcus* sp. on citrus tree{ *Chrysomphalus aonidum* (L.){ *Chrysomphalus aurantii* MASK.*Pseudaonidia duplex* (CKLL.)Tortoricid larva on *Elaeagnus* sp.Cynipid gall on *Quercus serrata*{ *Coccus hesperidum* L.{ *Pulvinaria camelicola* SIGM.{ *Kermes* sp. on *Celtis sinensis*{ *Takahashia* sp. on *Celtis sinensis*{ *Chilocorus kuzwanae* SILVESTRI{ *Coccinella bruckii* MULS.*Chrysopa boninensis* OKAM.*Pseudococcus* sp. on citrus tree*Thoracaphis* sp. on *Quercus glauca*, probably a secondary parasite*Ceroplastes floridensis* COMST.*Ericerus pela* CHAV.*Coccus hesperidum* L.*Kermes nazvae* KUW.{ *Coccus hesperidum* L.{ *Lecaniodiaspis quercus*{ *Pulvinaria camelicola* SIGM.{ *Pulvinaria horii* KUW.{ *Pulvinaria aurantii* CKLL.{ *Pulvinaria psidii* MASK.{ *Ceroplastes floridensis* COMST.{ *Ceroplastes rubens* MASK.*Nezara antennata* SCOTT. (Egg)*Porthetria dispar* L. (Egg)

Parasites	Hosts
<i>Pareusemon studiosum</i> ISHII	<i>Coccus hesperidum</i> L.
<i>Phaenodiscus eriococci</i> sp. nov.	{ <i>Eriococcus lagerstracmiae</i> KUW. <i>Eriococcus onukiï</i> KUW.
<i>Psyllaephagus iwayaensis</i> sp. nov.	Psyllid on <i>Cinnamomum</i> sp.
<i>Psylledontus viridiscutellatus</i> sp. nov.	Psyllid on <i>Elaeagnus umbellata</i>
<i>Tyndarichus nazae</i> HOWARD	<i>Porthetria dispar</i> L. (Egg)

Hosts	Parasites
HYMENOPTERA	
Cynipid gall	<i>Cynipencyrtus flavus</i> sp. nov.
COLEOPTERA	
<i>Chilocorus kuzvanæ</i> SILVESTRI } <i>Coccinella bruckii</i> MULS. }	<i>Homalotylus flammivius</i> (DALM.)
<i>Scymnus</i> sp.	<i>Anisotylus albifrons</i> ISHII
LEPIDOPTERA	
<i>Porthetria dispar</i> L.	{ <i>Ooencyrtus</i> ( <i>Schedius</i> ) <i>kuzvanæ</i> HOWARD <i>Tyndarichus nazae</i> HOWARD, a secondary parasite
Tortricid larva	<i>Copidosoma komabae</i> (ISHII)
NEUROPTERA	
<i>Chrysopa boninensis</i> OKAM.	<i>Isodromus axillaris</i> TIMB.
HEMPTERA	
<i>Nesara antennata</i> SCOTT.	<i>Ooencyrtus</i> ( <i>Ooencyrtus</i> ) <i>nesaræ</i> sp. nov.
Psyllid on <i>Cinnamomum</i> sp.	<i>Psyllaephagus iwayaensis</i> sp. nov.
Psyllid on <i>Elaeagnus umbellata</i>	<i>Psylledontus viridiscutellatus</i> sp. nov.
<i>Thoracaphis</i> sp. on <i>Quercus glauca</i>	<i>Aphidencyrtoides thoracaphis</i> sp. nov.
<i>Thoracaphis</i> sp. on <i>Quercus glauca</i>	<i>Metacerafterocerus fortunatus</i> (ISHII), probably a secondary parasite

Hosts	Parasites
<i>Aclerda japonica</i> NEWSTEAD	<i>Astymachus japonicus</i> HOWARD
<i>Antonina craxi</i> CKLL.	<i>Anagyrus antoninae</i> TIMB.
<i>Aspidiotus bambusarum</i> CKLL.	<i>Anabrolepis japonica</i> ISHII
<i>Ceroplastes ceriferus</i> AND.	{ <i>Anicetus ceroplastis</i> sp. nov.
	{ <i>Cheiloncurus ceroplastis</i> ISHII
<i>Ceroplastes floridensis</i> COMST.	{ <i>Microterys clauseni</i> H. COMPERE
	{ <i>Microterys speciosus</i> ISHII
<i>Ceroplastes rubens</i> MASK.	{ <i>Cheiloncurus ceroplastis</i> ISHII
	{ <i>Microterys speciosus</i> ISHII
<i>Chrysomphalus aonidum</i> (L.) }	<i>Comperiella bifasciata</i> HOWARD
<i>Chrysomphalus aurantii</i> MASK. }	{ <i>Anicetus annulatus</i> TIMB.
	{ <i>Aphycus orientalis</i> H. COMPERE
<i>Coccus hesperidum</i> L.	{ <i>Aphycus pulvinariae</i> HOWARD
	{ <i>Encyrtus barbatus</i> TIMB.
	{ <i>Microterys flavus</i> (HOWARD)
	{ <i>Microterys kuwanai</i> sp. nov.
	{ <i>Parusemion studiosum</i> ISHII
<i>Coccus pseudomagnoliarum</i> (KUW.)	{ <i>Anicetus annulatus</i> TIMB.
	{ <i>Aphycus orientalis</i> H. COMPERE
<i>Eriococcus lagerstraeimiae</i> KUW. }	<i>Phaenodiscus eriococci</i> sp. nov.
<i>Eriococcus onukiï</i> KUW. }	<i>Anagyrus sawadai</i> sp. nov.
<i>Eriococcus</i> sp. on <i>Cryptomeria japonica</i>	<i>Microterys ericci</i> ISHII
<i>Ericerus pela</i> CHAV.	<i>Anicetus annulatus</i> TIMB.
<i>Eucalymmatum tessellatum</i> SIG.	<i>Aphycus timberlakei</i> ISHII
<i>Eulcanium</i> sp. on <i>Euonymus europaea</i>	<i>Aphycus pulvinariae</i> HOWARD
<i>Eulcanium</i> sp. on <i>Euonymus</i> and <i>Vitis</i>	{ <i>Aenasioidea tenuicornis</i> TIMB.
<i>Kermes miyasakii</i> KUW.	{ <i>Blastothrix kernivora</i> sp. nov.
	{ <i>Cheiloncurus tenuicornis</i> sp. nov.
<i>Kermes naxosae</i> KUW.	{ <i>Blastothrix kernivora</i> sp. nov.
	{ <i>Microterys interpunctus</i> (DALM.)



## Hosts

- Kermes* sp. on *Celtis sinensis*  
*Kermes* sp. on cherry tree  
*Lecaniodiaspis quercus* CKLL.  
*Pseudaonidia duplex* (CKLL).  
*Pseudaonidia paconiae* CKLL.
- Pseudococcus* sp. on citrus tree
- Pseudococcus* sp. on *Ficus erecta*  
*Pulvinaria aurantii* CKLL.  
*Pulvinaria camelicola* SIGN.  
*Pulvinaria horii* KUW.  
*Pulvinaria psidii* MASK.  
*Pulvinaria* sp. on *Mallotus japonicus*  
*Pulvinaria* sp. on *Pittosporum tobira*  
*Pulvinaria* sp.  
*Takahashia* sp. on *Celtis sinensis*

## Parasites

- Encyrtus sasakii* sp. nov.  
*Aphycus albopleuraris* ASHMEAD  
*Microterys kutwanai* sp. nov.  
*Comperiella unifasciata* ISHII  
*Anabrolepis extranea* TIMB.
- { *Anagyrus subalbipes* sp. nov.  
*Cheiloncurus nagasakiensis* sp. nov.  
*Clausenia purpurca* ISHII  
*Leptomastix citri* sp. nov.
- Anagyrus alboclavatus* sp. nov.  
*Microterys okitsuensis* H. COMPERE
- { *Encyrtus barbatus* TIMB.  
*Microterys kutwanai* sp. nov.  
*Microterys kutwanai* sp. nov.  
*Microterys okitsuensis* H. COMPERE
- Anagyrus flavus* sp. nov.  
*Anicetus annulatus* TIMB.  
*Aphycus albicornis* TIMB.  
*Encyrtus sasakii* sp. nov.

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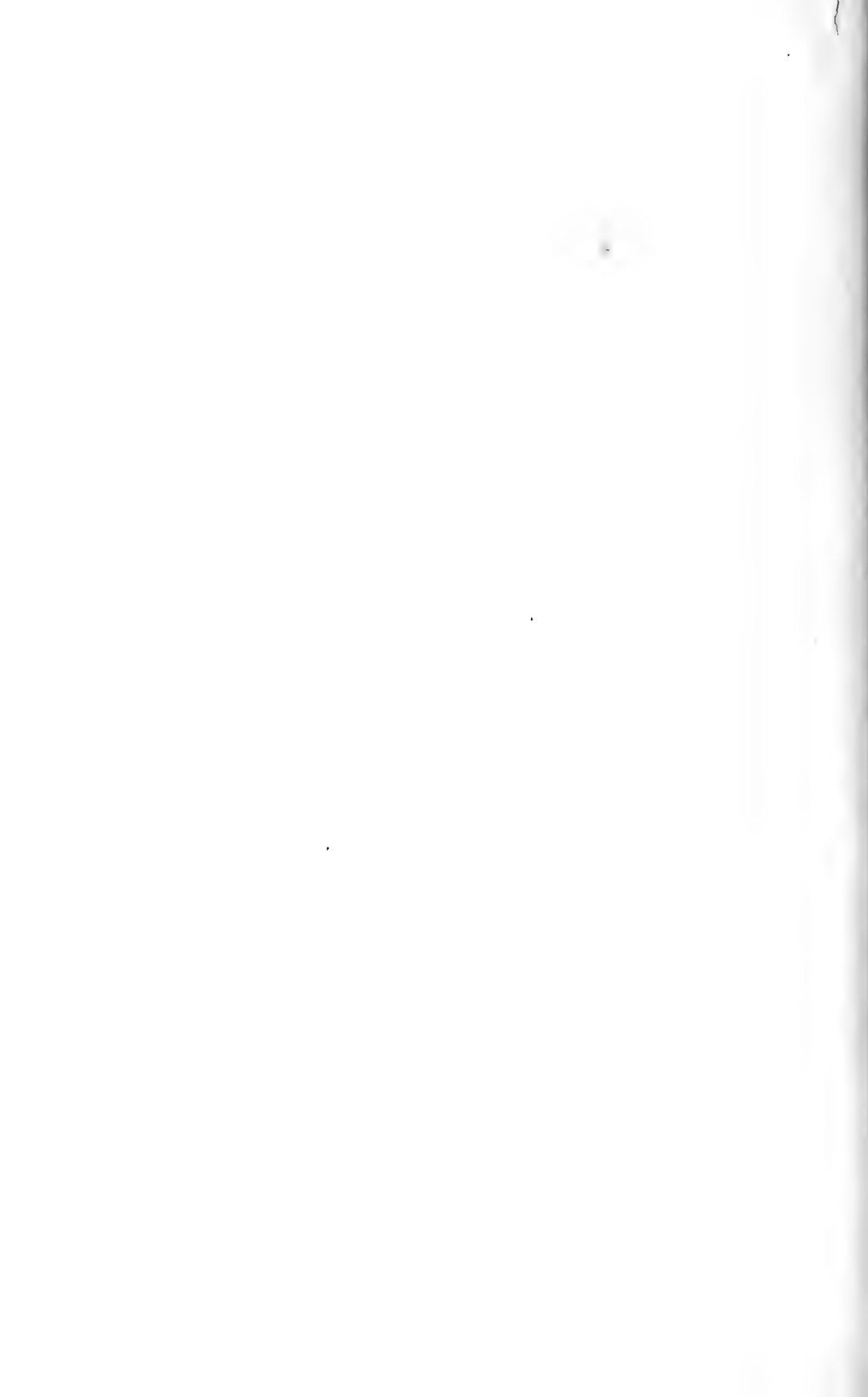
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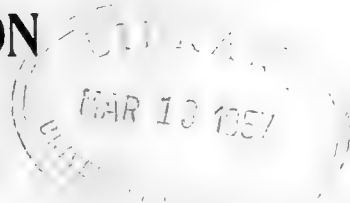
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— NOTICE —

You are hereby respectfully notified that the publication of the **Bulletin of the Imperial Agricultural Experiment Station**, excepting the special publications, will be discontinued after Vol. III, No. 3, and, in future all the Reports of this institution will be published in the **Journal of the Imperial Agricultural Experiment Station**.

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THE ENCYRTINAE OF JAPAN  
II. STUDIES ON MORPHOLOGY AND BIOLOGY

Tei ISHII

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INTRODUCTION

In continuation of a previous work concerning the classification of the Encyrtinae in Japan, an attempt was made to know the fundamental facts of their morphology and biology.

As is well known, most of the species belonging to the said subfamily are parasitic on various insects, especially Coccids, Psyllids and Aphids which are usually injurious to farm and fruit plants; consequently it may be stated that they are of a great economic importance in checking the injurious effect of the scale insects infesting fruit plants. Recently this biological control measure is practised with appreciate results in various countries. In California, the citrus trees were greatly damaged by *Saissetia oleae*, a scale insect originally introduced from South Africa. In order to control this serious insect pest, *Aphycus lounsburyi* was introduced from the latter locality in 1914 with successful results. In 1924 an attempt was made by F. SILVESTRI to introduce *Comperiella bifasciata*, a parasite of

*Chrysomphalus aurantii* and *Aspidiotus aonidum*, from Japan to California.

Here it might be mentioned that the present investigation was carried out chiefly at Nagasaki and partly in Tokyo extending from 1921 to 1928.

In this opportunity, the writer wishes to express his hearty thanks to Dr. I. KUWANA, Mr. S. KINOSHITA, Chief of the Division of Entomology, and Mr. S. KARIYA who rendered him encouragement and assistance during the course of this work. His thanks are also due to Prof. Dr. T. KABURAKI for the kindness in reading through the manuscript.

## MORPHOLOGY

### FEMALE ADULT OF *APHYCUS TIMBERLAKEI*

#### Head

(Pl. III)

In facial view the head is rather round in shape. Its face is convex, while the posterior surface is somewhat hollowed out and fits upon the anterior end of the thorax. Situated at the tip of the head, the vertex(vx), are ocelli(o). The front of the vertex is called the front(ft), in the lower part of which are found the antennae(ant), each inserted in a small circular, membranous socket of the head wall, which we call the toruli(tor). The antennae consist of 11 joints: the basal joint, the scape(scp), is long; the second joint, the pedicel(p), is short; the following six joints, funicle joints(f), are almost equal; the last club-shaped joint, the club(cl), is composed of three joints. Just below the front lies the clypeus(clp) which is, in this species, not separated by any suture from the front. Lateral to the vertex and front occur a pair of large oblong compound eyes(e). The parts below the compound eyes are the genae(ge) and the lower halves of the compound eyes are postgenae(pge). On the posterior side of the head we find the foramen magnum(for), the region around it being occipital region(oc).

Situated at the lower part of the head are the mouth parts, which are composed laterally of the mandibles(md) and maxillae(mx), and medially

of the labrum(lm) and labium(lb). The labrum is a little transverse flap, which attached to the lower part of the clypeus, forming the upper lip. It is set with minute hairs on the general surface and several strong hairs on the apical margin. The mandibles are rather large, strongly chitinised, and bear three teeth which are almost equal in shape and size. They are also marked with many bristles and longitudinal fullows. The maxillae consist of the stipes(st), cardo(cd), galea(ga), and lacinia(lc). The cardo is a small basal triangular plate, from the base of which a rather long process arises backwards, being articulated to the maxillary suspensorium(ms). The stipes is a large plate. The galea and lacinia are combined together, to form the terminal lobe. From the base of the galea, on the outer side, arise the maxillary palpi(mxplp). The maxillary pulpus is made up of four joints, of which the terminal joint is long and bears several long bristles. The stipes are sparsely beset with short hairs. The galea, the outer terminal lobes of the maxillae, is somewhat pointed at the apex and closely beset with bristle-like hairs. The lacinia, the inner terminal lobes of the maxillae, is triangularly produced inwards and rather thickly beset with minute hairs. The labium(lb) constitutes the lower lip of the mouth. Its basal part is called the submentum(sm), which is suspended laterally by the cardo of the maxillae. The next part is the mentum(mt), which bears the labial palpi(lbplp) on its upper side and is marked with minute hairs on its upper lateral sides, and with a pair of strong bristles near the apex. The labial pulpi are composed of three joints, sparsely covered with minute hairs, the terminal joint bearing several strong hairs. The terminal lobes of the labium are called the glossa(gl), which is covered with minute hairs.

In order to examine the internal structure, the head, after being dealt with a solution of NaOH, was imbedded in paraffin and then was carefully sliced off longitudinally by means of a sharp razor.

The internal skeleton of the head, or the entocranium, consists chiefly of two large, oblique, chitinous bars forming a brace between the anterior and the posterior wall of the head. These bars arise on each side of the

foramen magnum, and end at the internal side of the face just above the antennal sockets. They are named by MACLOSCKIE (1881) the mesocephalic pillars(ten). The base of these pillars is connected with a slender bar(ten) forming an arch over the foramen magnum. This bar and two pillars represent what is called in other insects the tentorium. The tentorium in the present form is so highly modified that it is hard to regard its parts as homologous with the parts of the X-shaped tentorium in the lower generalized insects. SNODOGRAS (48, p. 31) says that in the honey bee the two pillars represent the separated halves of the X-shaped tentorium, while the slender arch is an additional structure.

### T h o r a x

(Pl. IV, A, B)

The thorax is found as in other Hymenoptera, to consist of three leg-bearing segments, as well as of the first abdominal segment. The cephalic or first segment is named the prothorax; the second or intermediate, the mesothorax; and the third or caudal, the metathorax and the fourth, the propodeum.

The prothorax is represented by a very narrow band, only visible just anterior to the main thoracic segment. The dorsal plate which is called the pronotum(nI) forms a collar, encircling the front of the mesothorax, and presents a median transverse narrow groove, dividing it into two parts, the anterior scutum and the posterior scutellum. The lateral region of the prothorax is represented by a plate which is called the propleurum. The propleurum(PII) is a triangular plate representing both the lateral and the ventral surface. Ventrally situated behind the propleurum is the sternum(sI).

The mesothorax constitutes the most part of the thorax. The tergum is composed of a large anterior scutum(sct2), and a small but very prominent posterior scutellum, which are separated by a distinct suture. The scutellum(scl2) presents two antero-lateral areas, called the axillae(al), which are partially separated from the median area by sutures.



The postscutellum(p scl), which constitutes, with its phragma(pph2), the postnotum, is concealed by invagination within the cavity of the thorax. The lateral arms of the postnotum can be seen just behind the posterior wing process of the mesonotum. On each side of the mesothorax are found two plates, the prepectus(ppct) and the mesopleurum(pl2). The prepecti are regarded as derived from the anterior parts of both the sternum and the episterna. The mesopleura are quadrate plates, presenting no trace of suture. The ventral plate is the mesosternum(s2) which takes a part in the formation of the entosternum or the furca(fu).

The metanotum(n3) is a very narrow transverse sclerite widening on the sides, where it exhibits wing processes(anp, pnp). The metapleura are fused with the first abdominal segment, constituting the antero-lateral parts of the median segment or the propodeum. The median segment or propodeum(1t) is the true first abdominal segment and consists of a single sclerite bearing the first abdominal spiracles(1sp) laterally.

### **Wings and their articulation**

(Pl. V, Figs. A—D)

The fore wings are attached on each side to the posterior half of the mesonotum by the axillaries. The anterior notal wing process(anp) is large and is protruded posteriorly from the posterior corner of the mesoscutum, while the posterior process (pnp) is carried by the scutellum. The first axillary(1ax) is articulated to the anterior wing process of the notum, while its anterior neck, to the base of a large and conspicuous scale-like plate on the humeral angle of the wing base, which is the basal remnant of the subcosta(sc). The second axillary(2ax) rests upon the wing process of the pleurum and is articulated to the base of the radial vein. Its inner edge is articulated to the first axillary, and its posterior end, to the third. The third axillary(3ax) is associated with the base of the anal vein(a), and its posterior end is articulated to the fourth axillary(4ax) which is very small and articulated to the posterior wing process of the notum(pnp). The venation of the fore wing is very simple,

the veins being fused together and obsoleted. The costal vein is obsoleted, and the subcostal vein can be found at the humeral angle of the wing base as a large and conspicuous scale-like plate. The radial and medial veins are fused together, constituting a vein called the submarginal vein(subm). The first branch of the radius constitutes the marginal(ma) and post-marginal(postm) veins and the radial sector, called the stigmal vein(stigm). The cubitus is completely obsoleted, leaving only the median plate. The anal veins(a) are fused together, being represented as a vein at the base of the wing.

The hind wings are attached on each side to the metatergum, and are articulated to the anterior wing processes by the axillaries. In the hind wing three axillaries are present, the fourth being absent. The base of the subcosta and radius are fused to form a large humeral mass, and the radius and media are fused together, representing the so-called submarginal vein. At the tip of the submarginal vein there are hooklets(h) which are attached to the front wing in flight. The third axillary is articulated directly to the posterior notal wing process of the metatergum. The base of the fore wing is covered by a large scale called the tegula(tg) which is attached by means of the axillary membrane to the part between the humeral angle of the wing base and the edge of the notum.

### Legs

(Pl. V, E-H)

The legs are attached to the ventro-lateral regions of each thoracic segment between the pleurum and the sternum and behind the middle of the segment. They consist of the coxae(cx), trochanter(tr), femora(fe), tibiae(tb), and five-jointed tarsi(tar). The tibiae are provided with a spur(spr) at the tip on the ventral side, and the spur of the middle tibia is specially developed for the use of jumping. At the tip of the middle tibia and on the ventral side of the basal four joints of the middle tarsus are found stout spines. The last tarsal joint is beset at the tip with a pair of claws(cla) between which are the pulvillus(pul).

### Abdomen

(Pl. IV, A, B)

The abdomen appears to consist of nine segments, but it should be remembered that the true first segment is attached to the thorax, as already mentioned. Each segment consists of the tergum(t) and sternum(s), the former reaching far down on each side of the segment to cover the edge of the sternum. The second segment is very small, being attached transversely to the propodeum. Segments 3-9 are almost equal in length, and the tergi of segments 7-9 are deeply emarginated on each side. The tenth segment is very small, and opens the anus at the tip. The spiracle occurs on each side of the eighth segment. On each side of the abdomen near the middle part there is a remarkable organ which is known as plaque tactile au setigere (E. BUGNION 4, p. 509) or as tactile plate (A. L. EMBLETON 17, p. 248) or as vibrissal plate (P. H. TIMBERLAKE 63, p. 564). This organ consists of an oblong plate transversely to the length of the body, its pointed end being on the inner side. On the plate there are three long hairs. These organs may be of a sensory character. As to these organs many authorities are inclined to regard them as characteristic appendages in the Aphelinae and Encyrtinae). A. D. IMM: states as follows:—"Situated at the base of the apical segment of the abdomen, and fitting into a lateral sinus on the hind border of the preceding segment, is a small sensory plate, 0.015 mm. in diameter. Each plate carries three delicate setae, of which the longest measures 0.12 mm. in length. The plates are very characteristic structures among Aphelinae and Encyrtinae, and the setae to which they give basal support are apparently sensory in function." P. H. TIMBERLAKE (63, p. 564) mentions that these plates are usually called spiracles by most authors but as pointed out by ALICE L. EMBLETON they are probably tactile plates and have no connection with the spiracles. They are characteristic of the Encyrtidae and especially of the Encyrtinae.

The writer is of the view that these plates are homologous to the cerci of the tenth segment which are found in most insects. They are

set apart from the tip of the abdomen in association with the deep emarginations of the posterior margins of segments 7-9. The development of the plates is not so conspicuous in species belonging the Aphelinae.

### Ovipositor

(Pl. IV, E)

The ovipositor consists of three pairs of long, closely appressed blade-like processes called gonapophyses. These six pieces lie close together to form an organ by means of which the female deposits eggs in host insect. The segments give rise to a pair of gonapophyses in the eighth and two pairs in the ninth. Of the gonapophyses the shaft is a spear-like rod made up of three-paired pieces and presents a central canal throughout. One of those pieces is dorsal and is known as the sheath(*sha*), which is homologous to the median pair of the gonapophyses on the ninth segment, while the other two, the lancets(*lct*), are ventral and homologous to the gonapophyses on the eighth segment, and slide lengthwise on the track-like ridges of the dorsal piece. These dorsal and ventral pieces form the basal bulb(*shb*) at the base and are each continuous with the basal arm on the same side.

Each arm of the sheaths is supported at the end by an oblong or inner plate(*ob*). Each lancet is attached at the base to the triangular or fulcral plate(*tri*) which lies latero-dorsal to the base of the oblong plate. The triangular plate is articulated to a knob on the dorsal edge of the oblong plate at the postero-ventral angle, and to the quadrate or outer plate(*qd*) at the postero-dorsal angle. The quadrate plate extends posteriorly along above the posterior margin of the true eighth sternum. The triangular and quadrate plates are said to belong to the eighth sternum, and the oblong plate belongs to the ninth sternum.

### Digestive canal

(Pl. VI, A, B)

The mouth leads posteriorly into the pharynx(*phy*), which is con-

tinuous with a slender canal, the oesophagus(oe). This transverses the entire length of the thorax and opens into the crop(cr) or ingluvies. The crop is a large body with a thin wall. Next comes the narrow, neck-like proventriculus(pvent). Following this is the ventriculus(vent) or stomach which is of a large size and ovate in shape. This is continuous with the hind intestine(hint), where nine malpighian tubules(mal) make their way at the anterior part. The malpighian tubules are slenderly cylindrical and about as long as the ventriculus. Following the hind intestine is the round rectum(rec), which is abruptly narrowed posteriorly and opens out through the anus(an), which is situated at the end of the tenth segment.

### **Nervous system**

(Pl. VI, A, C)

The nervous system of the adult is rather simple, principally consisting of the supraoesophageal ganglion or brain(br), suboesophageal ganglion(soeang), three thoracic ganglions(1-3 gang), and a long mass of the abdominal ganglions(agang). The supraoesophageal ganglion is a large body lying in the upper most part of the head cavity. The suboesophageal ganglion is much smaller than the former, and is united with it by the circumoesophageal commissures. The three thoracic ganglions are of the same form and size, and are situated above the prosternum, mesosternum and poststernum respectively. The mass of the abdominal ganglions is elongate, gradually widens towards the end, and is provided with four pairs of lateral branches.

### **Respiratory system**

The respiratory system is very simply. Only three pairs of spiracles open to the exterior; the first is very inconspicuous, being situated at the posterior angle of the prothorax; the second, at the sides of the propodeum; the third, at the eighth abdominal segment. These three pairs are connected by short tubes with the main tracheal trunks, which run longitudinally on both sides of the thorax and abdomen. The main tracheal trunks

are connected anteriorly, at the prothorax, by the anterior transverse ventral loop, and posteriorly, at the seventh segment, by the posterior transverse ventral loop. From the anterior loop arises a pair of tracheal branches which proceeds towards the head. Besides those above mentioned, many minute tracheae are found to ramify in the body.

### Genital organs

(Pl. VI, E, F)

The genital organs consist of a pair of ovaries(ov), a pair of oviducts (ovd), vagina(vag), spermatheca(spm), and poison glands. The ovaries are very voluminous and occupy a position in the latero-dorsal parts of the abdomen.

They are made up of three pairs of ovarioles(ovl) which form convolution with one another. The ovarioles open into the anterior end of the oviduct on the same side of the body. The oviducts converge posteriorly and open into the vagina, which is considerably swollen near the tip. The posterior part of the vagina(vag) is called the bursa copulatrix (bcpx). On the dorsal part of the vagina there is the globular spermatheca connected with the vagina by a short cannal (condotto recondatore of GRANDI). The spermatheca is associated with a globular accessory gland (ghianola della spermateca of GRANDI). The poison glands consist of two parts, one acidic and the other alkaline. Both the glands open into the base of the ovipositor. The acid gland(acid) is a rather broad cylindrical tube, being abruptly narrowed at a short distance before its opening into the oval reservoir or poison sac(pnsnc). The wall of the poison sac is lined with a thick coat of chitin, and transversely striated. The alkaline gland(bgl) is a short and very inconspicuous tube, opening directly into the base of the ovipositor bulb, ventral to the opening of the poison sac.

#### MALE ADULT OF *APHYCUS TIMBERLAKEI*

### Genitalia

(Pl. IV, C, D)

On account of the similarity of the abdomen in general features to

that of the female, mention will be made merely of the genitalia. The male genitalia is developed from the true ninth sternum, being extruded from the posterior margin of the latter. It consists of the sheath(sh), claspers(cls), and penis(pen). The sheath is oblong chitinous sac. The penis is extruded from the sheath and is a semitransparent elongate tube, at the tip of which there are several minute pores. Attaching to the middle of the posterior margin of the sheath, there is a pair of claspers which are beset with two spines at the tip.

### **Genital organs**

(Pl. IV, D)

The genital organs consist of a pair of testes(tes), vesiculae seminales (ves), vasa deferentia(vdef), and ductus ejaculatorius(ejd), and penis. The testes are of a large oblong shape, being placed just below the fourth tergite. The vesicula seminalis follows immediately the testis which is oval in shape and much smaller than the latter. The vas deferens is short and slightly swollen, pale brown in colour, and opens immediately into the accessory gland(acgl) which is a little larger than the vesicula seminalis. The accessory glands open at the base of the ejaculatory duct which makes its way to the exterior at the penis.

### MATURE LARVA OF *APHYCUS TIMBERLAKEI*

#### **Head and body**

(Pl. VII, A—D)

The mature larva is spindle-shaped and translucent white in colour. It measures about 1.95 mm. in length and 0.75 mm. in width. The body comprise 13 segments (s 1-13), exclusive of the head. The head is rather small and more or less chitinized. As seen from the above, it is semi-circular in shape, and circular in frontal view. It increases its rigidity by the tentorium. The tentorium(ten) consists of two short, broad posterior arms, a transverse central body, and two anterior arms, of which the anterior two line the postero-ventral margin of the head, and the

third extend cephalad and dorsad, lining above the mouth. The antennae (ant) are seen as small papillae. The labrum(lm) is only represented by a flap, not separated from the clypeus, and possesses four pairs of minute papillae(p) on it. The mandibles(md) are sharply pointed at the tip, widening towards the base. The maxillae and labium are almost fixed together, and there can be discernible only delicate folds separating them. They are provided with two small papillae(p) respectively. On each side of the mouth there is a minute papilla. The body segments gradually shorten distally and have the surface bare and smooth.

### Digestive canal

(Pl. VII, A)

The digestive canal is divided into three parts, the oesophagus(oe), the middle intestine(mint) and the hind intestine(hint). The oesophagus is a slender canal, passing through the head and the anterior part of the first thoracic segment, and opens into the voluminous middle intestine which occupies the most part of the body cavity and ends at the posterior part of the tenth segment. Following the middle intestine is a short, narrow canal, called the hind intestine. It is not communicated with the middle intestine until a little before the prepupal stage. Opening into the base of the small intestine are the malpighian tubules(mal), eight in number, of which three are broad and five are slender. Following this hind intestine is the rectum(rect) which is moderately swollen and opens out through the anus.

A pair of long tubular salivary glands(svgl) lies on each side of the digestive canal. Their ducts converge anteriorly and join in the hind region of the head to form a median common duct, which makes its way to the floor of the mouth.

### Nervous system

(Pl. VII, A)

The nervous system consists mainly of the brain(br) or supra-oesophageal ganglion, suboesophageal ganglion(soegng) and ventral nerve



cord(nv). The supraoesophageal ganglion is made up of two oval ganglia connected with each other, and lies in the dorsal cavity of the head. The suboesophageal ganglion occupies a position in the ventral cavity of the head below the oesophagus and are united with the supraoesophageal ganglion by the circumoesophageal commissures(ccer). The ventral nerve cord is simple, ending at the posterior part of the tenth segment. Its ganglia are inconspicuous and are merely discernible as very feeble swellings.

### **Respiratory system**

(Pl. VII, C)

There are nine pairs of spiracles located on the first and 3rd-10th segments. The spiracle leads into a short tube connecting with the main tracheal trunk which runs longitudinally on both sides of the body. The main tracheal trunks are united together anteriorly by the anterior tracheal loop(atral) in the first segment, and posteriorly by the posterior tracheal loop(ptral) in the eleventh segment. Two pairs of tracheal branches from the anterior loop extend towards the head, and from the longitudinal trunks branches are given off dorsally and ventrally in each segment.

### **Muscular system**

(Pl. VII, D)

The muscles of the larva is, in general, degenerated. In the head the levator muscles of the phypopharynx(lmp) and of the epipharynx(lme) are developed to a considerable extent. This is due to the fact that the mouth fits to swallow the foods by the expansion and contraction of the buccal cavity. In the body a uniform arrangement of muscles prevails in all segments with the exception of the last segment in which the number of muscles is more or less reduced. The main body muscles are represented by the ventro-longitudinal(vlm), latero-oblique(lom) and dorso-longitudinal(dlm) muscles. The ventro-longitudinal muscles are longitudinally arranged in a cephalo-lateral direction. They are flat, about five in number, and are disposed on either side of the mid-ventral line, close to the

hypodermis, extending between the anterior and the posterior margin of each segment. In spite of the presence of the major lateral oblique muscles, there are no minor lateral oblique muscles. The former extends between the anterior and the posterior border of each segment. Their anterior ends are attached to the body wall directly adjacent to the line of the attachment of the posterior ends of the ventro-longitudinal muscles. From this point each of these muscles runs lateral and caudad to the attachment on the posterior border of the segment at the marginal muscle. The dorso-longitudinal muscles comprise a set of narrow bands, about five on each side, lying just beneath the dorsal body-wall. These are longitudinally arranged, being connected at the anterior margins of each segment.

## BIOLOGY

The following observations are based not only upon *Aphycus timberlakei* but also upon species common in Japan, especially parasitic on scale insects infesting the citrus tree.

### Behaviors of Adults

The Encyrtid-flies, though generally active on shiny days, are rather sluggish on cloudy or rainy days, usually resting on the under side of leaves. Among those flies *Homalotylus flamineus* is the most active and runs about the leaves or twigs on fine days. It scarcely flies except when some enemy approaches. On the latter occasion it jumps quickly. Usually it moves towards the light.

### Feeding Habits of Adults

In the field the flies feed on the juice secreted by some Aphids and scale insects. In confinement they are fond of honey or sugar diluted with water. Some species take the body fluid of the host passing through the punctures made by their ovipositor. The writer observed the same

habit in *Microterys speciosus* (the writer, 28,p.78) and *Bassus lactatorius* (the writer, 27,p.224). The same is also the case with *Tetrastichus anthomelaenae*, a parasite of the Elm leaf-beetle (*Galerucella luteola*) and *Aphelinus mytilaspidis* (L. O. HOWARD, 23,pp.357-360), *Meraporus* sp. and *Pteromalus puparum*, parasites of the pupa of *Ephesitia kuchuicella* (F. A. JOHNSTON, 30,p.144), *Aphelinus mytilaspidis* (A. D. IMMS, 25,p. 329), *Aphelinus diaspidis*, a parasite of *Chrysomphalus aurantii* (QUAYLE, 1910), *Blastothrix sericea*(?), a parasite of *Pulvinaria vitis* (NEWSTEAD, 1903), *Pimpla (Itopectis) conquisitor*, a parasite of *Autographa brassica* (F. A. JOHNSTON, 30,p.144) and *Aphelinus laspisignii*, a parasite of *Aphis bakeri* (L. P. ROCKWOOD, 45,p.415).

### Longevity of Adults

The longevity of the flies differs according to sexes, foods and temperature conditions. In general the flies can live much longer in the field than in confinement in glass tubes or rearing cages. They live usually only for three or four days without food, while they, when fed with honey diluted with water, would live much longer. The following list shows the longevity of different species which were fed with diluted honey and kept in a light place of the room.

Name	Date of emergence	Sex	Date of death	Longevity
<i>Paracemion studiosum</i>	May 12, 1926	Female	July 10, 1926	59 days
<i>Anicetus annulatus</i>	" 19 "	"	" " "	52 "
<i>Microterys clausei</i>	April 14 "	"	" 6 "	83 "
<i>Homalotylus flamineus</i>	June 3 "	"	June 9 "	6 "
<i>Comperiella bifasciata</i>	August 19 "	"	August 30 "	11 "
" "	" " "	Male	Sept. 15 "	27 "
" "	" " "	Female	" 23 "	35 "
<i>Encyrtus sasakii</i>	May 24 "	"	May 28 "	4 "
" "	" 23 "	"	" 30 "	7 "
<i>Syrphophagus</i> sp.	April 29 "	Male	" 5 "	6 "
<i>Aphycus pulvinariae</i>	" " "	"	" 2 "	6 "

As is self-evident from the above, the females of *Microterys clauseni*, *Anicetus annulatus*, *Parausemion studiosum*, *Comperiella bifasciata* and *Microterys speciosus* can live for a considerable duration. While those of *Encyrtus sasakii* and *Homalotylus flamineus* live only for 4-6 days. The latter species are much more active as compared with the former. The longevity of the males is usually much shorter than that of the females.

### Matin g

So far as observations go, mating normally take place shortly after emergence which occurs in the male a little earlier than in the female. The male runs after the female, and as soon as quickly mount on the body of the latter, bends the abdomen, attaching its tip to the genital opening of the female. Copulation may take place more easily when they are exposed to the sun light, and usually lasts for few seconds. The female does not mate more than once, in spite of that the male repeatedly copulates.

### Oviposition

The female begins to deposit eggs about one day after mating, so far as observed in *Aphyus timberlakei*, *Aphyus pulvinariae*, *Comperiella bifasciata*, *Clausenia purpurca*, *Microterys speciosus* and *Microterys flavus*. The manner of oviposition in *Comperiella bifasciata* will be noted here.

When coming near the suitable host with the vibration of the antennae, the flies turn round and then insert the ovipositor into the host body through the lateral part of the scale, bending slightly their abdomen. On this occasion the lancets or stylets and sheath take a part in the formation of a minute pore in the scaly covering of the host. After the formation of the pore the sheath of the ovipositor is withdrawn, leaving the lancets in situ. The whole process of oviposition is completed in 1-7 minutes. The female in general does not repeat oviposition in the same scale, with the exception of that of *Aphyus timberlakei* and *A. pulvinariae*, both

parasitic on *Lecaneum sp.*, which repeatedly deposit eggs, their number differing according to the size of the host. The female of *Clausenia purpurea*, a parasite of *Pseudococcus sp.* on the citrus tree, inserts its ovipositor into the body of the first stage larva of the host, suspending it with the ovipositor while an egg is deposited.

In the majority of Encyrtids the eggs deposited are suspended in the host body with a stalk, the end of which is protruded outside the host skin. The position of egg deposition is definite in certain species, for example, *Microterys clauseni* (Pl. VII, E) through the anus of the host, *Ceroplastes floridensis*, *Microterys flavus* usually in the central part of the host, *Coccus hesperidum*. In *Aphycus timberlakei* and *A. pulvinariae* it is not confined to a definite place of the host body.

The number of eggs deposited by parasites in a single host body differs in different species and also in the size of the host body. It is only one in *Comperiella bifasciata*, one or more in *Microterys speciosus* and *M. clauseni*, only one in *Aphycus timberlakei*, when the host, *Lecaneum sp.*, is still young and small, but more than one as the host develops. The writer bred 26 adult males from a single scale of *Lecaneum sp.*

As to the total number of eggs deposited by a single female which may differ in different species and in temperature conditions, the writer is not in a position to make out clearly. On dissection of several females *Aphycus timberlakei* was found to contain in an average 172 mature ovarian eggs in the oвалies.

### Eggs and Hatching

(Pl. VIII, A—I)

The ovalian eggs are composed of two bodies connected by a slender stalk or tube. The larger body is the egg proper, within which the embryo later develops. At the tip of the smaller body is found a micropyle. The surface is minutely reticulated, especially in the stalk and the basal part of the larger body. In *Comperiella bifasciata*(D) is translucent white in colour and contains minute granular substances. The larger

body is about 0.11 mm. long by 0.06 mm. wide, while the smaller body is about 0.07 mm. long by about 0.04 mm. wide and the stalk is 0.13 mm. in length. In *Aphycus timberlakei* (H) it is of the same colour, its larger body being about 0.1 mm. long by 0.06 mm. wide, the smaller one 0.04 mm. long by 0.03 mm. wide, and the stalk 0.03 mm. in length. In *Microterys speciosus* the larger body is about 0.3 mm. long by 0.12 mm. wide. The stalk is very long, being 0.67 mm. In *Encyrtus sasakii* (C) the larger body is 0.13 mm. long by 0.06 mm. wide, while the smaller body is 0.09 mm. long by 0.06 mm. wide. The stalk is rather long and bends at the middle. It measures 0.06 mm. in length. In *Homalotylus flamineus* (I) the stalk is short.

The deposited eggs are usually of an oblong shape, bearing a short or long stalk at the broad end. They are translucent white or pale brown, and are minutely reticulated on the surface. In *Comperiella bifasciata* (E) the egg is long oval in shape, translucent white in colour and is provided with a moderately long stalk at the broad end. The chorion is minutely reticulated. The egg is about 0.19 mm. long by 0.05 mm. wide, and the stalk is 0.05 mm. in length. In *Aphycus timberlakei* the egg is oval in shape and translucent white in colour, with a short stalk at the broad end. The chorion is almost smooth. The length is 0.1 mm., the width is 0.05 mm., and the length of the stalk is 0.04 mm. In *Microterys speciosus* it is oblong in shape and pale brown in colour, with a very long pedicel or respiratory tube at the posterior extremity. The chorion is minutely reticulated. The egg measures about 0.24 mm. long by 0.1 mm. wide, and the stalk is 0.18 mm. In *Microterys flavus* (F) the egg is similar in shape to that of the above species, but slightly smaller. In *Homalotylus flamineus* it is oblong in shape with a very short stalk, and measures 0.19 mm. long by 0.09 mm. wide.

The incubation period may differ in different species and in temperature conditions. As a whole it is rather short, usually being a few days. It was only two days in August (1926) in *Comperiella bifasciata* and four days in June (1922) in *Microterys speciosus*.

As the embryo develops, the egg gradually becomes larger in size. Just before hatching, the larva moving slowly in the egg shell can be observed. The shell is at last broken at the tip by the force of the movement of the larva. After hatching the larvae are still attached in certain species at the posterior part of the abdomen to the egg shell, while they are set in other species free from the shell.

### Larval Stages

(Pl. IX)

In the Encyrtids there are usually five, occasionally four larval stages. Each stage may be determined by the number of the mandibles which are attached to the molted skins or exuviae in the posterior part of the abdomen in such species as *Compericella bifasciata* and *Microterys speciosus*. However, in the larvae which have no molted skins attaching to the posterior part, it is very difficult to determine the stage. F. SILVESTRI (48, p. 49) demonstrated five larval stages in *Phaenodiscus acneus* and *Microterys lunatus*, and four stages in *Encyrtus infidus*, *Blastothrix sericea* and *Aphycus punctipes*.

In the following a record is given of the larval stages of *Compericella bifasciata*.

**FIRST STAGE (A):** The newly hatched larva is of a spindle shape, tapering towards the posterior end, and translucent white in colour. The body segments can be faintly distinguished. The head is small and slightly narrower than the first segment. The mouth is provided with the mandibles (M) which are sharply pointed upwards, and measure 0.008 mm. long by 0.003 mm. wide. The body cavity is filled with the large mid-intestine and granular fat bodies. The respiratory system is not discernible. The body is about 0.24 mm. in length and 0.07 mm. in width.

**SECOND STAGE:** The larva is quite similar in shape and colour to the first, with the exception of its larger size. It measures 0.33 mm. in length and 0.09 mm. in width. The mandibles is 0.007 mm. long by 0.011 mm. wide.

**Third Stage (B):** The larva is spindle-shaped, much stouter than the preceding, and translucent white in colour. The number of the body segments amounts to 13, exclusive of the head. The body cavity is filled with granular fat bodies. The tracheal system is not yet developed. The mandibles(M) are much stouter than in the preceding stage, measuring 0.015 mm. long by 0.019 mm. wide. The body measures 0.49 mm. in length and 0.22 mm. in width.

**Fourth Stage:** The larva is similar in shape and colour to the preceding, excepting its larger size. The tracheal branches are slightly developed, and the fat bodies are segmentarily congregated. The mandibles(M) are almost similar to those of the third stage, measuring 0.02 mm. in length and width. The body measures 1.02 mm. long by 0.02 mm. in wide. The body measures 1.02 mm. long by 0.44 mm. wide.

**Fifth Stage (C):** The larva is similar to that of the fourth stage in shape and colour, but its body is a little larger than that of the latter. The head is rather small, its shape being semicircular in dorsal view and transversely oblong in frontal view. The antennae are very small and papilla-shaped. There can be seen six pairs of papillae in the labium, two pairs in the maxillae, and three pairs in the labrum. Further on each side of the mouth occurs a rather large papilla. The mandibles(M) are similar in shape to those of the fourth stage, measuring 0.03 mm. in length and 0.026 mm. in width. The body is 1.2 mm. long by 0.48 mm. wide. The tracheal system is well developed, and the stigma counts nine pairs in all, opening on segments 1 and 3-10. The fat bodies are segmentarily congregated. The body is 1.2 mm. in length and 0.48 mm. in width.

*Aphycus timberlakei*(F): The first stage larva is oval in shape and translucent white in colour. The head is small, and has the mandibles sharply pointed at the tip and measuring 0.01 mm. in length and width. The body segments are not distinct, and the body is filled with large mid-intestine and granular fat bodies. In the respiratory system the longitudinal and transverse tracheal loops are merely developed.



The body is about 0.24 mm. in length and 0.17 mm. in width.

Of the mature larva(F) mention was already made.

*Pareusemion studiosum*(I): The mature larva is of the usual type, with nine pairs of spiracles. The mandibles(J) are sharply pointed at the apex and abruptly widened towards the base. The salivary glands are of a brownish colour at the base, probably due to the secretory substance, which renders the host scale brownish. The body is 1.87 mm. in length and 0.75 mm. in width.

*Encyrtus barbatus*(G): The first stage larva is elongate spindle in shape and translucent white in colour. The tenth body segment gives rise on each posterior side to a long tail-like appendage, which is considerably longer than the body, and is attached to the egg shell at the tip. Through the appendage passes the tracheal branch(tra); consequently the air is taken through the egg pedicel or stalk(es). The head is small and has the sharp mandibles. Two pairs of spiracles are found opening on segments 3 and 9 respectively. The body is 1.32 mm. in length and 0.29 mm. in width.

*Cerapterocerus mirabilis*(K): The larva of this species was described by F. SILVESTERI (48, p. 107). The first stage larva is of the type different from that of the above mentioned species. The head is large and long, and the last segment is long and tapers like a tail, being provided with sparse numbers of spines. The body is 1 mm. in length and 0.15 mm. in width.

As may be evident from the above there can be distinguished some five types of the first stage larvae in the Encyrtids.

First Type. The larvae of *Copidosoma*, *Litomastix* and *Syrphophagus* which produce polyembryos. The larvae are destitute of mandibles, spiracles and sense organs such as antennae and papillae.

Second Type. The larvae of *Microterys*, *Phaenodiscus* and *Blastothrix*, which are oval or spindle-shaped. The head is provided a pair of papila-like antennae and mandibles. There are nine pairs of spiracles,

of which those on the tenth segment are especially developed. The respiratory system is metapneustic.

Third Type. The larva of *Encyrtus*, which is almost similar to the second type and has the respiratory system metapneustic. It is provided a tail-like appendage on each side of the tenth segment, through which passes the tracheal branch. Two pairs of spiracles are opened on segments 2 and 9 respectively.

Fourth Type. The larvae of *Aphycus* and *Comperiella*, which are ovate or spindle in shape. The head is provided, besides sense papillae, with papilla-like antennae and mandibles. The spiracles are not developed. The respiratory system is apneustic.

Fifth Type. The larva of *Cerapterocerus*, which is elongate spindle in shape. The head is large and long, and the last segment tapers like a tail which is provided with sparse numbers of spines. The respiratory system is apneustic.

#### Feeding Habits of Larvae and their Effects on Hosts

With regard to the feeding habits of parasitic Hymenopterous larvae observations have been made by many authorities. REAUMUR and HARTIG (1837) state that "La larve parasite s'attaque au corps grasseux." RATZBURG (44, p. 13) mentions that the larvae of internal parasites feed upon the lymph and blood rather than upon any of the solid tissues. È. BUGNON (4, p. 449), à propos de la larve de l'*Encyrtus fuscicollis*, dit qu'elle se nourrit exclusivement de la lymphe; ce n'est qu'à la fin qu'elle dévore tout. J. PÉREZ, according to M. SEURAT (47, p. 104), says as follows:—"Assurément que les larves de *Microgaster glomeratus* ne se nourrissent, dans le corps de la Piéride, que du tissu adipeux et du sang exclusivement, respectant les viscères; le tube digestif ne présente pas la moindre blessure." L. O. HOWARD (22, p. 575) states that the old idea that parasitic larvae feed upon the fatty tissue in a mandibulatory manner seems, at least in majority of cases, to be not true, and the feeding upon the lymph and blood is only applicable to *Apanteles* and related genera, which

often leave the host in a living but comatose condition.

Most Encyrtid-larvae feed upon the lymph and blood in the early stages, while the nearly mature larvae feed not only upon the lymph and blood but also upon the fat bodies and internal organs except the tracheal system, as well as upon *Saccalomyces spp.* (Pl. X, H), which are often found in scale insects. The larvae damage to a considerable degree the tissues of the host bodies probably due to the action of their secretory substance. The larva of *Encyrtus sasakii* seems to feed merely on the lymph and blood of the host, and matures in the latter which is still living. The larva of *Pareusemion studiosum* renders the host, *Coccus hesperidum*, brownish, probably due to the secretory substance from the salivary glands, as mentioned above.

#### Respiration of Larvae

According to RATZBURG (1844) and WEISSENBERG (1908), the larva of *Apanteles glomeratus* (Braconidae), a parasite of *Pieris brassicae*, breathes through the tail-like appendage which is formed by the evagination of the hind intestine and filled with blood. The heart produces a flow of lymph through the tail which functions as a blood gill, and oxygen is derived from the blood of the host. BLEADOWSKY and KRAINSKA (1926) also made observations on the respiration of the larva of *Banchus femoralis* (Ichneumonidae). It is believed that the endoparasitic larvae without any tail-like appendage breathe through the skin, taking oxygen from the blood of the host (C. SHRÖDER, p. 265). A. D. IMMS (26, p. 358) states that the first and second stage larvae of *Aphycus melanostomatus* are apneustic, respiration taking place through the body wall. M. SEURAT (47, p. 105) states as follows:—"La respiration des jeunes larves internes, non encore pourvues de trachées remplies d'air s'effectue par osmose à travers la peau, par toute la surface du corps; les larves munies de la vésicule anale ou de l'appendice caudal respirent également par toute la surface du corps, y compris ces appendices; mais on ne peut admettre que ces appendices délient toute la fonction respiratoire; ils manquent, en

effet, dans beaucoup de cas (Aphidides, Chalcidides, etc.)". P. H. TIMBERLAKE (60, p. 85) places on record, in his studies on the biology of *Limnerium validum* (Ichneumonidae), as follows:—"In the case of larvae observed immediately after hatching, the tracheal system can be made out easily, and is filled with air without doubt, though necessarily of the closed of apneustic type, only one fine tracheal branch could distinguished in the tail, and it was clearly not important enough to indicate that the tail is a tracheal gill. The function of the tail, however, is probably respiratory, and the organ might probably be termed a blood gill. There is nothing in its structure to contradict this view, as it is simple, hollow tube lined with hypodermal cells, and undoubtedly filled with blood a greater part of the time. Since the larva lies free in the body cavity of the host it is constantly bathed in blood and lymph fluids, from which the oxygen of its own blood must be derived through the delicate integument of the tail, or other parts of the body, especially while still small.

He further states (p. 89) as follows:—"The shortening of the tail appendage in the second stage and its entire disappearance in the third stage must necessitate a gradual change in the respiratory habits of the larva, if, indeed, the tail in a truly respiratory organ, as we think it must be. This change is perhaps correlated with the more ravenous appetite of the parasite in the last two stage of its larval life, and also with the gradual disappearance of the blood and lymph of the host. With the disappearance of the fluids of the host, the tail as a blood gill must necessarily become useless, as it is fitted for life in a fluid medium only. Nor does it seem possible, for much the same reason, that the larva's whole supply of oxygen is gained by osmosis through the integument of the body itself, for as the larva grows older the integument becomes thicker and tougher left is to consider that the oxygen is derived from the comparatively enormous amount of food taken in during this period, and that it is absorbed by the blood of the larva through the walls of its digestive tube. In other words, if the larva stopped feeding it would not only starve but also suffocate. Toward the end of the third stage, however,

when the host is nearly or possibly not entirely consumed the stigmata become open, and the larva is able to breath air directly, as it certainly does after leaving the host to spin its cocoon.”

The respiration of the Encyrtid-larvae may be classified into two types, metapneustic and apneustic. In the former type the newly hatched larva is suspended in the body cavity of the host by means of a long pedicel or respiratory tube which makes its way through the integument of the host to the exterior. The larva is capable of breathing freely the atomospheric air through the apex of the pedicel. To this type belong *Microterys*, *Phaenodiscus*, *Encyrtus* and *Blastothrix*. The larvae of those take air through the pedicel until a little before they mature.

In the second type the larva lives freely in the host and takes oxygen either from the blood of the host through the skin or from the blood absorbed through the wall of its digestive tract.

### **Amaebocytosis or Phagocytosis**

(Pl. X, I)

While dissecting *Coccus hesperidum* and *Antonia craxi* the writer found dead larvae of *Microterys flavus* in the former and of *Anagyrus antoninae* in the latter, which were encysted in a tough, dark brown capsule, besides a healthy larva. This phenomenon is known as amaebocytosis or phagocytosis, and has been studied by several authorities, especially by P. H. TIMBERLAKE (1912) and C. P. CLAUSEN (1924). TIMBERLAKE (60, p. 75), after observing this phenomenon in *Limnerium validum*, states that the amaebocytic reaction takes places regularly when the *Limnerium* occurs in the host, to which it seems to be unaccustomed and unadapted, and the capsule is blood-tissue or amaebocyte. He (p. 76) also mentions as follows:—

“The phenomenon of amaebocytosis brings up the question, why do not all parasites suffer the same fate, and what constitutes adaptation? We begin here to sink deep into the quagmire of speculation and doubt. We may say that the parasitic larva is so similar to the host in its effluvia

or physical being, that its presence is not felt or resented, and that it bears much the same relation to the host that the fetus within the uterus does to the mammalian mother; or we may conclude that it secretes substances into the blood which paralyze the protective reaction of the host. We are more inclined to accept the latter view, for we have observed several phenomena in the course of other dissections which are difficult to explain except by a secretion hypothesis. . .” C. P. CLAUSEN (63, p. 271) states in his study of the parasites of *Pseudococcus maritimus* as follows:—“This phagocytosis apparently has nothing to do with the death of the larva, but is merely a reaction set up in the body of the host by the presence of dead foreign matter. It is difficult to explain satisfactorily the causes which give rise to this constant death of all larvae but, one immediately after hatching. Even when several of these minute larvae are present in a mealy bug’s body measuring from three to five millimeters in length, it seems extremely improbable that contact can occur between the different larvae except by accident, as they may be widely separated, and in addition are incapable of moving about freely through the body fluids. The possibility of a combat among the larvae of the first instar for possession of the host therefore seems out of question. It seems also improbable that the death of the larvae can be result of any defensive reactions aroused in the body of the host, as a single larva experience no difficulty. Two theories may be advanced as to the cause of the death of the surplus larvae within a day after hatching. The first of these is that the hatching of the egg sets up gradually a chemical or other reaction in the body which is sufficient to kill those hatching later, yet the first larva in the meantime attains sufficient strength to overcome the attack. The second theory is that of the direct secretion by the newly hatched larva of some substance inimical to those following, as it may be presumed that the larvae at the moment of emergence from the egg are weaker and less able to withstand adverse conditions than after they fed even a few hours. This latter theory appears to be logical.”

On the contrary, it seems, to the writer’s mind, that the first theory

is more logical, because the capsule-like body around the parasitic larva may be of a phagocytic character. The capsule-like bodies which might be increased in the host body as a result of the reaction to the first hatched larva, probably make the latter hatched larva easily surrounded, and perish, as it appears to be of much feeble resistance.

### Pupation

As the larva matures, it acquires a paraffin-like envelope corresponding to the cocoons of other insects. Many authorities are inclined to think that this is of the last larval exuvia. L. O. HOWARD (22, p. 579) states as follows:—"With certain Encyrtinae, for one of which Dr. RILEY has proposed the excellent descriptive name of the "inflating chalcid-fly", particularly of the genus *Copidosoma*, but also of *Bothriothrix*, *Homalotylus* and perhaps others, the larvae, inhabiting the host insect in great numbers, when about to pupate cause a marked inflation in the larva by the formation of oval cells around the parasites. This inflation and the pupal cells which cause it are very noticeable in thin-skinned host larvae. With a small larva like that of *Lithocolletis* the appearance of Dipterous puparia is produced. The nature of this cocoon-like cell and the method by which it is produced are unknown. Its structure shows it is not to be silk, nor yet the last larval skin of the parasite, and whether it is an adventitious tissue of the host larva or a secretion of the parasite, is explicable upon other group, I can not say."

In *Copidosoma* and *Litomastix* which produce polyembryonic development the pupal envelope is derived from the eggs of parasites, this being known as trophamnion, while in other species it is made by a secretion from the salivary glands of the mature larva.

The writer observed a pale reddish brown fluid secreted from the mouth of the larva of *Microterys speciosus*. This fluid becomes soon hardened like a paraffin-like matter which is quite similar in texture to the envelope. The mature larva of *Encyrtus barbatus* (Pl. X, J) makes an envelope in a still living host, attaching it to the tracheal branches

of the latter. It would seem that by this means the parasite take air from the tracheal branches of the host.

After forming the envelope, the larva discharges pellet-like excrements and attains to the prepupal stage. The prepupa (Pl. VIII, L) is in general similar to the mature larva, exclusive of the possession of the thoracic segments which are of a comparatively large size. The buds of the wings and legs and genitalia are visible through the skin. The prepupa measures in *Comperiella bifasciata* 1.05 mm. long by 0.6 mm. wide and in *Aphycus timberlakei* 1.2 mm. long by 0.55 mm. wide.

The prepupa soon attains to the pupa, which, though generally pale white, gradually change its colouration and presents an aspect similar to the adult. The pupa (Pl. VI, G-I) measures in *Comperiella bifasciata* 1 mm. long by 0.6 mm. wide (female) and 0.97 mm. long by 0.52 mm. wide (male), and in *Aphycus timberlakei* 1.35 mm. long by 0.66 mm. wide (female) and 1.14 mm. long by 0.54 mm. wide (male).

### Emergence

(Pl. X, A—G)

The adult emerges within the host body where it remains for a short time. In *Comperiella bifasciata* the adult was found to remain for one day in the host body in May, 1926. At the time of emergence it cuts the host skin by means of its mandibles. In *Microterys flavus* it usually makes a hole on the dorsal side, posterior to the middle of the host scale. After emergence, the adult keeps its body clean with the legs and soon begins to walk.

### Sex ratio

In most species of the Encyrtids the female exceeds the male in number to a considerable degree, on account of the occurrence of the parthenogenetic generation which produce females only (Thelytokous). P. H. TIMBERLAKE (62, p. 195) puts on record that *Pauridia peregrina* and *Blepyrus mexicanus* can be reared through many generations without



presenting any male.

With regard to the sex ratio the writer had occasion in May, 1926, to examine the collection made in the neighborhood of Nagasaki with the following results.

Species	Number of specimens	Number of females	Number of Males	Percentage of females
<i>Aphycus timberlakei</i>	55	50	5	52%
<i>Aphycus pulvinariae</i>	132	93	39	70%
<i>Comperiella bifasciata</i>	150	100	50	66%
<i>Syrphophagus</i> sp.	10	3	7	30%

Here it might be noted that only the males, 23 in number, were reared from a single specimen of *Lecanum* sp. collected in the field on May 19, 1926. This may be due to the deposition in the host of eggs unfertilized.

### Parthenogenesis and Polyembryogenesis

As is well known, the parasitic Hymenoptera are in majority parthenogenetic. Among the Chalcidoidea *Pteromalus puparum*, according to ADLER (1876), produces only males (arrhenotokous). This similarity is also true of *Tanaomastix abnormis*, a parasite of the common citrus mealy bug, which is arrhenotokous when unfertilized (SMITH, 53, p.276). A. D. IMMS (26, p. 332), though he does not determine whether the offsprings are male or female, find that *Aphelinus mytilaspidis*, a parasite of the mussel scale (*Lepidosaphes ulmi*), undergoes parthenogenesis. According to P. H. TIMBERLAKE (61, p. 296), *Microterys flavus*, a parasite of *Coccus hesperidum*, when it reproduces parthenogenetically, is always arrhenotokous, whereas it, when fertilized, produces only females. According to H. S. SMITH and H. COMPERE (54, p. 315), *Aphycus lounsburyi*, a parasite of the black scale (*Saissetia oleae*), produces only females when the parent female is unfertilized, but gives both sexes when fertilized, as in the case of *Microterys speciosus*. So far as the writer's observations go, *Aphycus*

*timberlakei*, *Aphycus pulvinariae* and *Comperiella bifasciata* produce only males when the reproduction is parthenogenetic. In all probability most species of the Encyrtinae produce only males, when parthenogenetic, but not when fertilized. On the other hand, some species are thelytokous, such as *Microterys speciosus*. According to P. H. TIMBERLAKE (62, p. 195), *Adelencyrtus odonaspidis*, *Belpyrus mexicanus*, *Encyrtus infelix*, *Pauridia peregrina* and *Salonotum americanum* are generally of the thelytokous habit and rarely produce males. Needless to say, this thelytokous habit appears to be of a great advantage to a species which becomes established in a new region. On the contrary, the arrhenotokous habit may act disadvantageously before a species is well established, since the rapid dispersal which takes place will tend to increase the difficulties of the sexes finding each other, and thus restricts the necessary fertilization of the female.

According to P. MARCHAL, F. SILVESTRI, R. W. LAIBY, J. T. PATTERSON, H. L. PARKER, C. FERRIÈRE, C. G. HILL, there are in the parasitic Hymenoptera a number of species which undergo polyembryogenesis. There are the species which belong to the Chalcidoidea, Serphoidea and Braconidae. The first includes such Encyrtid-formes as *Ageniaspis fusicollis*, *Copidosoma buyssoni*, *Copidosoma nanellae*, *Copidosoma gelechiae*, *Copidosoma boucheanum*, *Copidosoma thompsoni* and *Litomastix kriechebaumeri*; the second, *Polygnotus minutus*, *Platygaster vernalis*, *P. himalis* and *P. variabilis*; the third, *Macrocentrus gifuensis*. The writer had occasion to find a chain of embryos of *Syrphophagus* sp. (Pl. X, K) in the larva of a Syrphid. It would seem that this species reproduce by polyembryogeny.

#### Host relation

The species of the Encyrtinae, though attacking the eggs and larvae of the Hymenoptera, Diptera, Coleoptera, Neuroptera and Rhyncota, are parasitic in majority on scale insects. The following are those which are parasitic on scale insects:—

*Astymachus japonica*, *Anagyrus antoninae*, *A. sawadai*, *A. subalbipes*, *A. alboclavatus*, *A. flavus*, *Aenasioides tenuicornis*, *Anabrolepis extranea*, *A. japonica*, *Anicetus annulatus*, *A. ceroplastis*, *Aphycus albicornis*, *A. albopleuralis*, *A. orientalis*, *A. pulvinariae*, *A. timberlakei*, *Blastothrix kermicola*, *Cheiloncurus ceroplastis*, *C. nagasakiensis*, *C. tenuicornis*, *Clausenia purpurea*, *Comperiella bifasciata*, *C. unifasciata*, *Encyrtus barbatus*, *E. sasakii*, *Leptomastix citri*, *Microterys clauseni*, *M. criceri*, *M. flavus*, *M. interpunctus*, *M. kuwanai*, *M. okitsucensis*, *M. speciosus*, *Pareusemion studiosum* and *Phaenodiscus eriococci*.

*Psyllaephagus iwayaensis* and *P. viridiscutellatus* are parasites of certain *Psyllids*; *Aphidencyrtoides thoracaphis*, of *Thoracaphis* sp.; *Ooencyrtus nezarae*, of the egg of *Nezara antennata*; *Cynipencyrtus flavus* was bred from a Cynipid gall. *Homalotylus flamineus* is a parasite of *Chilocorus kuwanai* and *Coccinella bruckii*; *Anisotylus albifrons*, of the larva of *Scymnus* sp.; *Copidosoma komabae* and *Litomastix* sp., of certain Lepidopterous larvae; *Isodromus axillaris*, of *Chrysopa boninensis*.

The species parasitic on a single host are:—

*Astymachus japonicus* attacks only *Aclerda japonica*; *Anagyrus antoninae*, only *Antonia craxi*; *Anabrolepis japonica*, only *Aspidiotus bambusarum*; *Pareusemion studiosum*, only *Coccus hesperidum*; *Clausenia purpurea*, only *Pseudococcus* sp.

The species parasitic on more than one host are:—

*Anicetus annulatus* attacks *Coccus hesperidum*, *C. pseudomagnoliarum*, *Eucalymnatus tessellatus* and *Pulvinaria* sp., and *Microterys kuwanai* attacks *Coccus hesperidum*, *Lecaniodiaspis quercus*, *Pulvinaria camericola* and *P. horii*.

Most of the species attacking scale insects have the preference towards the female host. However, *Microterys criceri* is found parasitic on the male larva of *Ericerus pe-la*.

As may be evident from the above, the closely related species are apt to attack the hosts which are also closely related together.

### Life cycle

*Comperiella bifasciata* passes three generations a year, the adults making their appearance in April, August and October. It hibernates in the first or second larval stage. The duration of the egg stage was two days in August, 1926; that of the larval stage, ten days; that of the prepupal stage, one day; and that of the pupal stage, five days. Consequently it may be stated that the said species requires 27 days in August, 1926, extending from the egg to the adult. *Aphycus timberlakei* passes three or four generations a year, the adults appearing from April to October. The duration from the egg to the adult was 27 days in May, 1926. *Microterys clauseni* seems to pass only one generation a year. The adult emerges in the early summer (June to July) from *Ceroplastes floridensis* in which it hibernates in the larval stage, and lives for a long duration, resting on trees, until the host scale grows to a moderate size. The adult of *Parcusemion stadiosum* emerges in the middle of April, hibernating in the pupal stage in the host, and then appears in May, July and September. The adult of *Clausenia purpurea* emerges in the middle of April, hibernating in the larval stage, and appears in June, July, August, September, October and November. The adult of *Cheiloneurus nagasakiensis* emerges in the end of April and then appears in May, July, August, and September. *Homalotylus flamineus* hibernates in the mature larva, and the adult may be collected in April, May, July, August and October. *Comperiella unifasciata* hibernates in the mature larva, and the adult appears in April, May, June and August. The adult of *Homalotylus flamineus* emerges in the beginning of April, hibernating in a mature larva, and it may be collected in May, June, July and August. *Anagyrus antoninae* hibernates in the mature larva, and the adult may be collected in April, June, July and August and October.

### Parasitism

*Homalotylus flamineus*, though parasitic on *Chilocorus kuwanae* and *Coccinella bruckii*, is parasitized in the larval stage by *Lygocerus* sp.

(Ceraphronidae). Sometimes it is checked by *Lygocerus* in about 70%. *Coccophagus* sp. is parasitic on the larvae of *Aphycus timberlakei* and *A. pulvinariae* and deposits an oblong egg. Occasionally found in a larva of *Microterys kuwanae*, a parasite of *Pulvinaria horii*, was an interesting larva (Pl. X, L) which is of the following character:—

The body is cylindrical in shape, tapering posteriorly like a tail, and translucent white in colour. The head is considerably large with the hook-like mandibles(md) crossing with each other. The body is composed of 13 segments, and the tail is provided with sparse numbers of spines. The respiratory system is not completely developed, only the longitudinal tracheal trunks being discernible. The body is 0.55 mm. in length and 0.13 mm. in width.

C. P. CLAUSEN (64, p. 258), in his studies of the parasites of *Pseudococcus maritimus*, records an instance of tertiary parasitism; *Thysanus elongatus* is a tertiary parasite of *Anagyrus subalbicornis*.

Unfortunately the writer has had no occasion to meet with tertiary parasitism. Occasionally an instance of superparasitism was observed in the case of *Coccus hesperidum*; a single scale is found infested with the larvae of two species, *Microterys flavus* and *Coccophagus yoshidae*.

#### Predaceous enemies

The adults of the Encyrtids are so highly active and quickly jump that they are not captured by the enemies which come near them. Ants are found sometimes to prevent the oviposition of the flies. Spiders are regarded as principal enemies of the flies, on account of their active predaceous habits.

#### ECONOMIC IMPORTANCE

Most species of the Encyrtids are parasitic on scale insects which are generally highly injurious to fruit and ornamental trees, and check the increase of the latter insects to a considerable extent. *Coccus hesperi-*

*dum* is one of the most important enemies of the citrus tree. However, in the districts of Nagasaki this insect is not so injurious as to require special remedial treatments. This is due to the fact that the scale insect is parasitized by *Anicetus annulatus*, *Aphycus orientalis*, *A. pulvinariae*, *Encyrtus barbatus*, *Microterys flavus*, *M. kucanae* and *Pareusemion studiosum*. Among these *Microterys flavus* is the most important species, its parasitism sometimes amounting to 50%. *Pareusemion studiosum* is also of the most important form, but its distribution is confined to some fields near Nagasaki. *Ceroplastes floridensis* is a common scale insect noxious to Citrus, certain fruit and ornamental trees. It is parasitized by *Microterys clauseni* and *Anicetus ceroplastis* of which the former sometimes checks as much as 70% of the scale. *Ceroplastes rubens* is one of the most injurious scale insects in the Southern parts of Japan. This is parasitized, though not at a high rate, by *Microterys speciosus* and *Cheiloncurus ceroplastis*. *Ceroplastes ceriferus* is a common scale insect, attacking chiefly ornamental trees, and is parasitized by *Anicetus ceroplastis* and *Cheiloncurus ceroplastis*. *Comperiella bifasciata* is one of the most important parasites of *Chrysomphalus aurantii* and *Aspidiotus aonidium* which infest the citrus tree. In April, 1926, *C. aurantii* was found parasitized by this species in about 17%. *Pseudoaonidia duplex* is a minor pest of the citrus tree in Japan. *Comperiella unifasciata* represents one of most beneficial enemies and attacks the scale insect in a considerably high percentage. It occurs also in Java where it is a parasite of *Aspidiotus destructor* and has been introduced from there to Sangi island, situated between Celebes and Mindanao islands, to control the scale insect injuring coconut plantations. *Pulvinaria aurantii*, an injurious scale insect of Citrus, is parasitized by *Microterys okitsuensis*. So far as is known, *Pseudococcus* sp. does not attack the citrus tree in Japan. This may be due to the parasitism of such four species of flies as *Cheiloncurus nagasakiensis*, *Leptomastix citri*, *Anagyrus subalbipes* and *Clausenia purpurea*. Among these the last is the most important parasite, and checks in a considerable high percentage. *Ooencyrtus kucanae* is an important para-

site of the egg of *Porthetria dispar*. This fly has been imported to the United State of America from Japan to control the insect pest. *Ooencyrtus nezarae* is parasitic on the egg of *Nezara antennata* which is injurious to beans.

Now let us pass on to a consideration of the injurious but not beneficial aspects of the Encyrtids. The lady beetles are considered as the most beneficial insects on account of devouring plant lice, scale insects and some other pests. *Chilocorus kuwanae*, an important enemy of the Diaspinae scale insects, is parasitized by *Homalotylus flamineus*, its increase being greatly checked by the parasite; about 51 % of larvae were found parasitized in May, 1922, in a field near Nagasaki. The same fly was found parasitic on larva of *Coccinella bruckii*, a common lady beetle devouring the Aphids. *Scymnus sp.*, a lady beetle devouring *Pseudococcus sp.* on Citrus, is parasitized by *Anisotylus albifrons*. *Chrysopa boninensis*, a feeder of *Prontaspis yanonensis*, is parasitized by *Isodromus axillaris*.

Further there are some species which are secondarily parasitic on other parasitic Hymenopterous insects. *Metacrafterocerus fortunatus* is probably parasitic on the larva of *Aphidencyrtoides thoracaphis* which is a parasite of *Thoracaphis sp.* on *Quercus glauca*. *Thyndaricus navae* is said to be a parasite of *Ooencyrtus kuwanae* which is parasitic on the egg of *Porthetria dispar*.

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## EXPLANATION OF PLATES

## Plate III.

A. Head of female of *Aphycus timberlakei*, frontal view. B. Same, posterior view. C. Same, transverse section. D. Mandible of the same. E. Maxillae and labium of the same. F. Maxilla of the same. G. Antenna of female of the same. H. Antenna of male of the same.

ant antenna; cd cardo; cl club; clp clypeus; e eye; f funicle; for foramen magnum; ft front; ga galea; ge gena; gl glossa; lb labium; lbplp labial palpus; lc lacinia; lm labrum; md mandible; ms maxillary suspensorium; mt mentum; mx maxilla; mxplp maxillary palpus; o ocellus; oc occiput; p pedicel; pge postgena; ppl propleurum; r ring joint; scp scape; sm submentum; st stipes; ten tentorium; tor torulus; vx vertex.

## Plate IV.

A. Head and body of female of *Aphycus timberlakei*, dorsal view. B. Body of the same, ventral view. C. Female genitalia of the same. D. Tip of lancet or stylet of ovipositor. E. Male genitalia of the same. F. Abdomen of male of the same.

al axilla; antl anterior leg; anp anterior wing process of notum; clp clasper; cx coxa; e eye; fu furca or median entosternal apodeme of thoracic sterna; gen genitalia; lct lancet; midl middle leg; n notum; o ocellus; ob oblong plate; pen penis; pf parasidal furrow; pl pleurum; pnp posterior notal wing process; pph posterior phragma or postphragma; posl posterior leg; ppct prepectus; ppl propleurum; pscl postscutellum; qd quadrate plate; s sternum; scl scutellum; sct scutum; sh sheath of penis; sha basal arm of sheath of ovipositor; shb bulb of sheath of ovipositor; sp spiracle; stnplp palpus-like appendage of ovipositor; t tergum; tg tegula; tp tactil plate; tri triangular plate of ovipositor.

## Plate V.

A. Fore wing of female of *Aphycus timberlakei*. B. Hind wing of the same. C. Base of fore wing of the same. D. Base of hind wing of the same. E. Fore leg of the same. F. Middle leg of the same. G. Terminal joint of tarsus of the same. H. Hind leg of the same.

a anal vein; anp anterior wing process of notum; ax axillary sclerite; cla claw; cx coxa; fe femora; h hook; m small median plate; ma marginal vein; n notum; pnp posterior wing process of notum; postm postmarginal vein; pul pulvillus; sc subcosta; sp spiracle; spr spur; subm submarginal vein; stig stigmal vein; t tergum; tar tarsus; tb tibiae; tr trochanter.

## Plate VI.

A. Diagrammatic representation of internal organs of female of *Aphycus timberlakei*, lateral view. B. Alimentary canal of the same. C. Nervous system of the same. D. Male genital organs of the same. E. Female genital organs of the same. F. Ovariole of the same.

G. Pupa of female of *Comperiella bifasciata*, ventral view. H. Pupa of the same, dorsal view. I. Pupa of male of the same, ventral view.

A. acid gland; acgl accessory gland; agang abdominal ganglion; an anus; B. alkaline gland; bcpx bursa copulatrix; bg1 alkaline gland; cr crop; dlm dorsolongitudinal muscle; ejd ejaculatory duct; gang ganglion; hint hind intestine; mal malpighian tube; oe oesophagus; ov ovary; ovd oviduct; ove ovarian egg; ovl ovariole; p poison sac; phy pharynx; psnc poison sac; pvent proventriculus; rect rectum; S spermatheca; soegn suboesophageal ganglion; spm spermatheca; tes testes; vag vagina; vdef vas deferens; vent ventriculus; ves vesicula seminalis.

### Plate VII.

A. Diagrammatic representation of internal organs of mature larva of *Aphycus timberlakei*, lateral view. B. Head of the same, frontal view. C. Tracheal system of the same. D. Muscular system of the same. E. Position of eggs of *Microterys clauseni* deposited in *Ceroplastes floridensis*. F. Tip of egg of the same. G. Position of egg of *Pareusemion studiosum* deposited in *Coccus hesperidum*. H. Position of egg of *Compericella bifasciata* deposited in *Chrysomphalus aurantii*.

an anus; anp anal plate; ant antenna; atral anterior tracheal loop; bl bud of leg; br brain; ccer crura cerebri; dlm dorsal longitudinal muscle; e egg; es egg shell; g gonapophyses; go genital organ; h head; hint hind intestine; lom lateral oblique muscle; lm labium; lme levator muscle of epipharynx; lmp levator muscle of hypopharynx; mal malpighian tube; md mandible; mint middle intestine; nv nerve; oe oesophagus; p papilla; ptral posterior tracheal loop; s segment; sp spiracle; soegn suboesophageal ganglion; svgl salivary gland; ten tentorium; tratr tracheal trunk; vlm ventral longitudinal muscle.

### Plate VIII.

A. Egg of *Microterys speciosus*. B. Ovarian egg of the same. C. Ovarian egg of *Encyrtus sasakii*. D. Ovarian egg of *Comperiella bifasciata*. E. Egg of the same. F. Egg of *Microterys flavus*. G. Egg of *Aphycus timberlakei*. H. Ovarian egg of the same. I. Ovarian egg of *Homalotylus flamineus*. J. Mature larva of *Comperiella bifasciata* forming an envelope. K. Pupa of the same in the shell of *Chrysomphalus aurantii*. L. Prepupa of the same.

exc exclement.

### Plate IX.

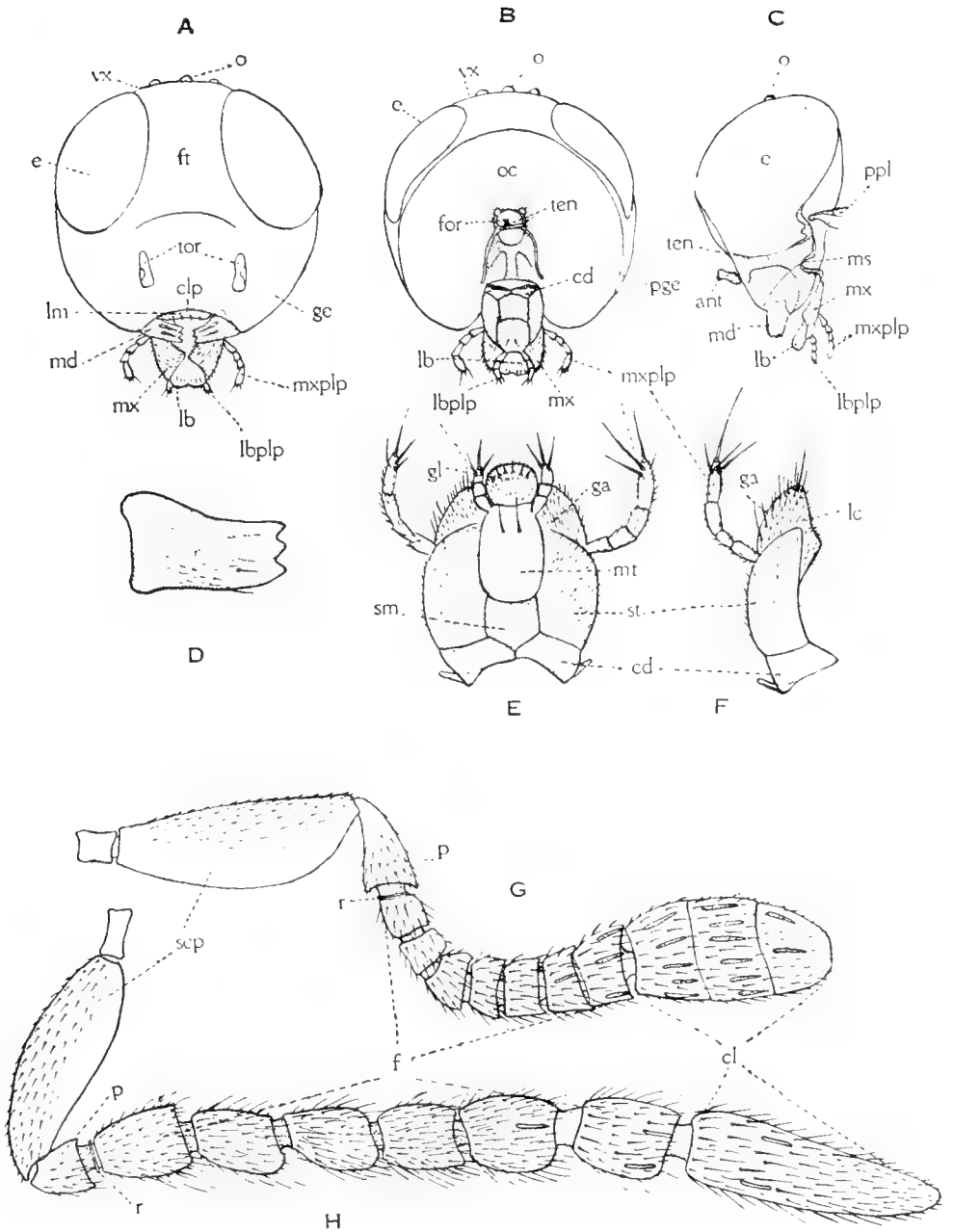
A. First stage larva of *Comperiella bifasciata*. B. Third stage larva of the same. C. Fifth stage or mature larva of the same. D. Head of the same, frontal view. E. First stage larva of *Aphycus timberlakei*. F. Fifth stage or mature larva of the same. G. First stage larva of *Encyrtus barbatus*. H. Mature larva of *Microterys speciosus*. I. Mature larva of *Pareusemion studiosum*. J. Mandible of the same. K. First stage larva of *Cerapterocerus mirabilis* (after F. SILVESTRI).

ant antenna; es egg shell; exv exuvia; fb fat body; M mandible; md mandible;  
p papilla; ped pedicel; sp spiracle; sh scale of host; ten tentorium; tra trachea.

### Plate X.

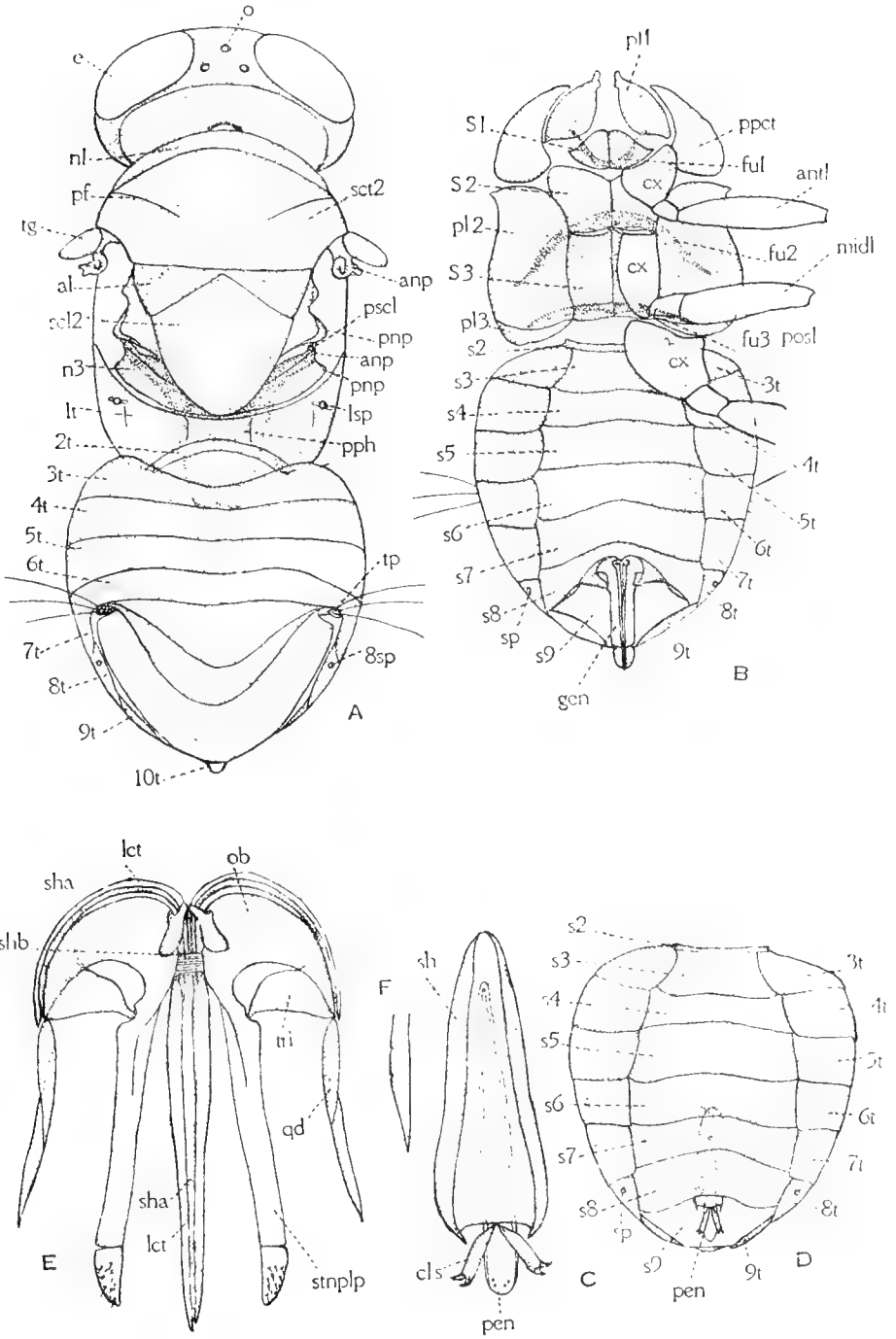
A. Emergence holes of *Microterys interpunctus* on *Kermes*. B. Same of *Comperiella bifasciata*. C. Same of *Copidosoma komabae* on a tortoricid larva. D. Same of *Microterys flavus* on *Coccus hesperidum*. E. Same of *Aphycus timberlakei* on *Lecaneum* sp. F. Same of *Microterys clauseni* on *Cerooplastes floridensis*. G. Same of *Homalotylus flamineus* on larvae of *Chilocorus kuwanae*. H. *Saccalomys* sp. I. Larva of *Anagyris antoninae* covered with phagocytes. J. Envelope of mature larva of *Encyrtus barbatus* and tracheal branches of host. K. Polyembryonic mass of *Syrphophagus* sp. L. Larva of a secondary parasite of *Microterys kuwanae*.

em embryo; env envelope; exc excrement; larv larva; md mandible; tr troph-  
amnion; tra trachea.

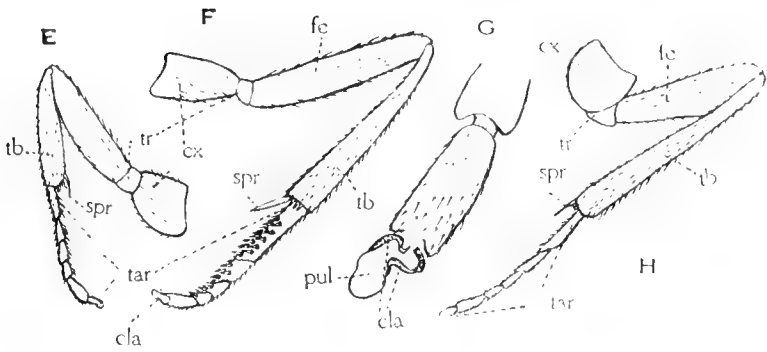
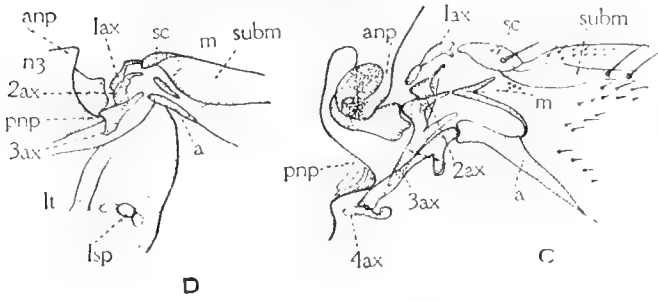
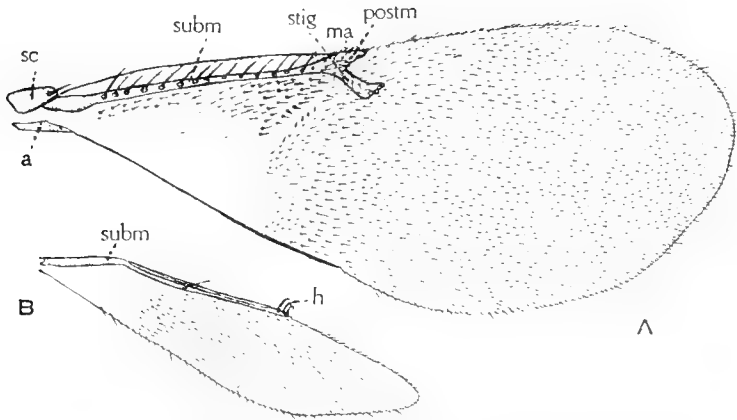




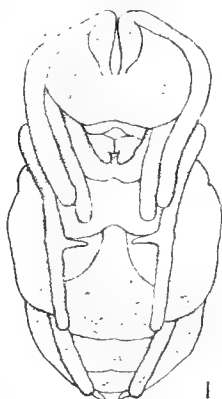
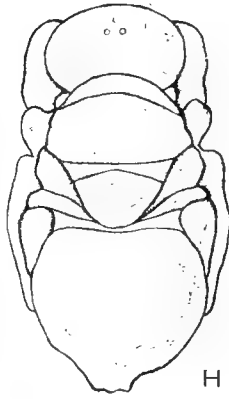
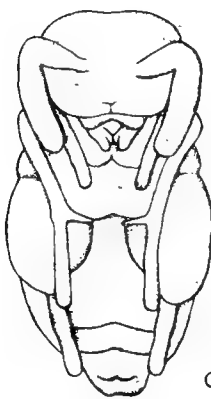
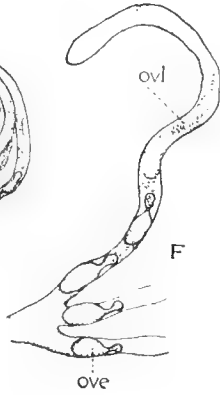
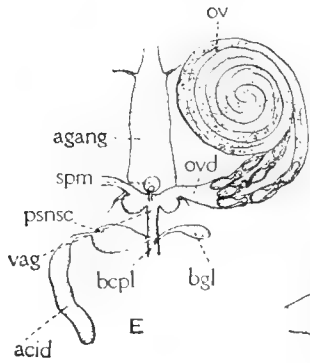
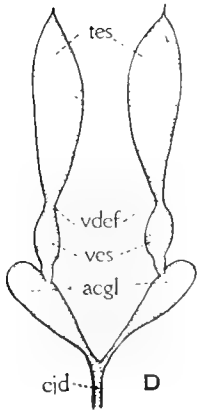
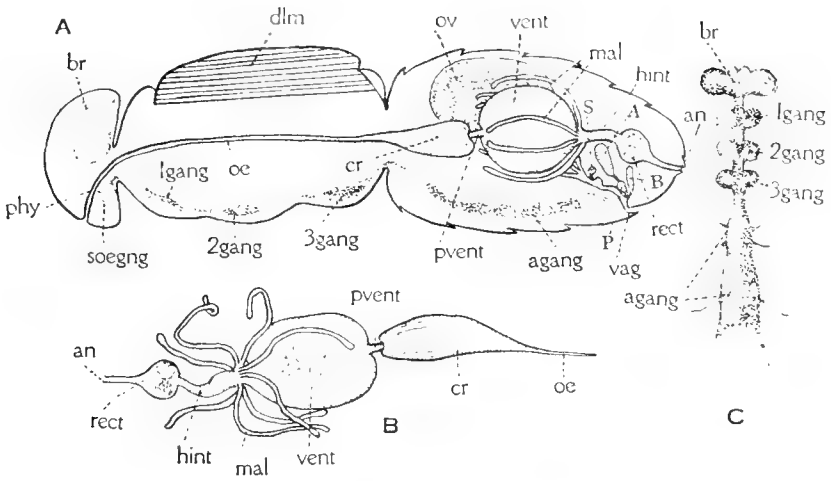




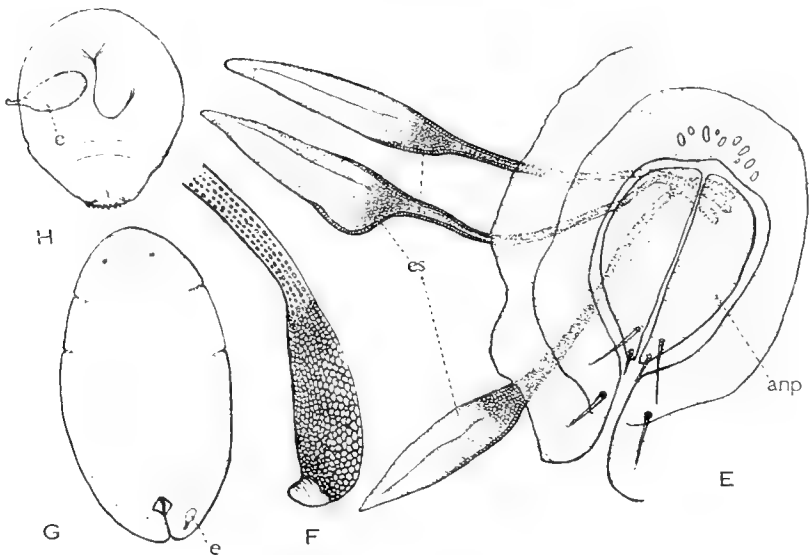
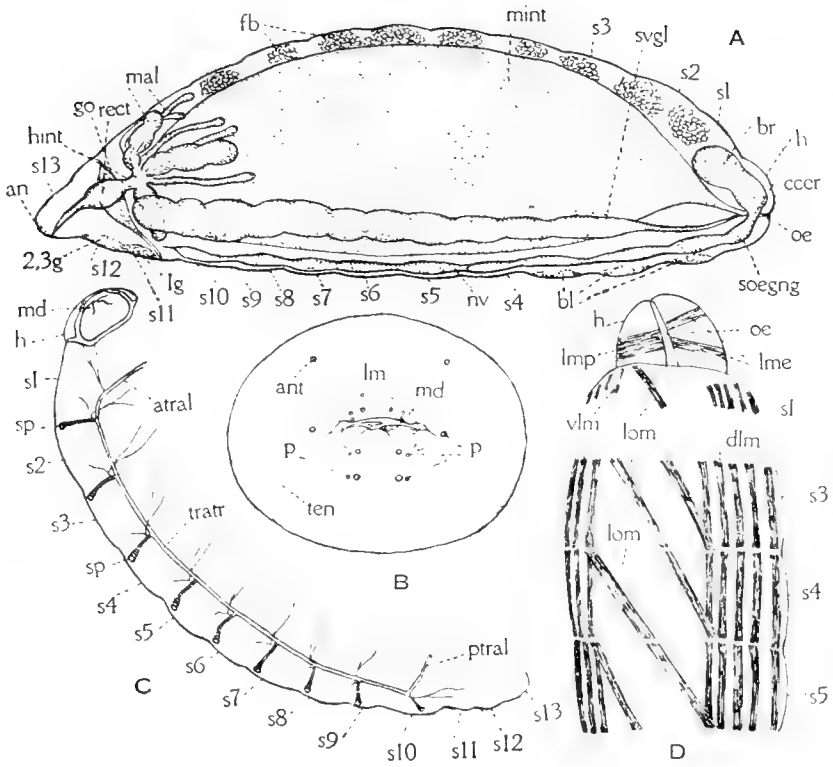






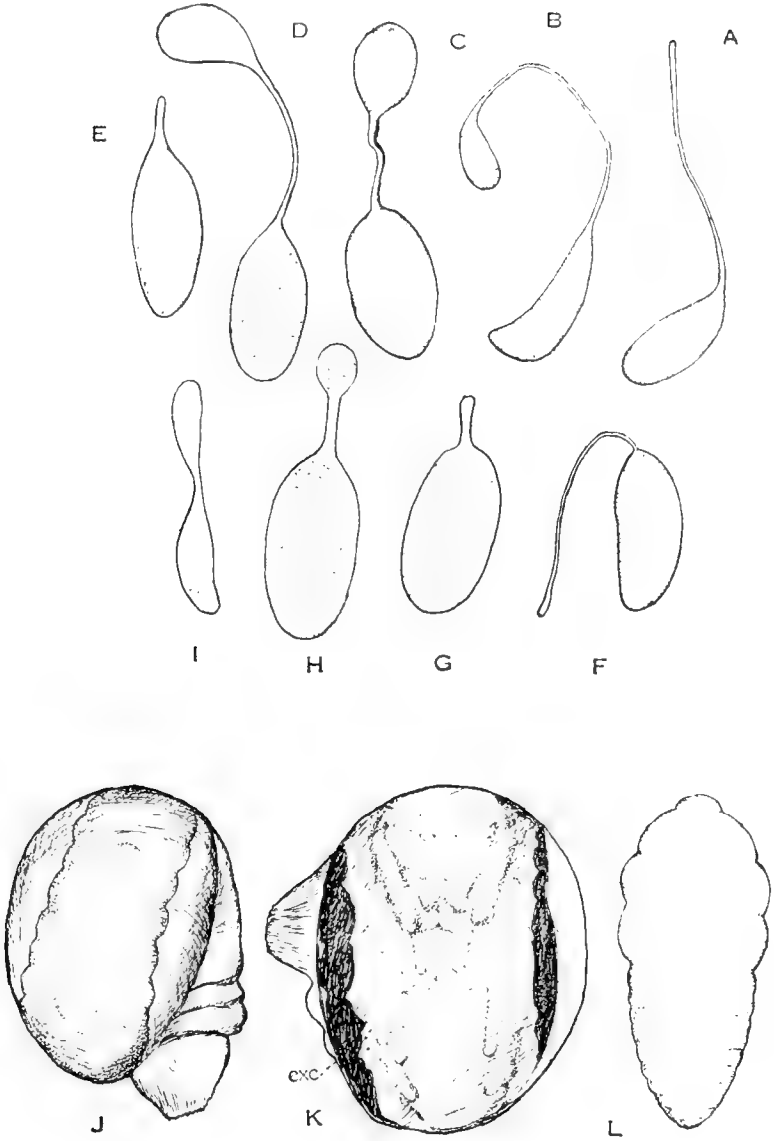




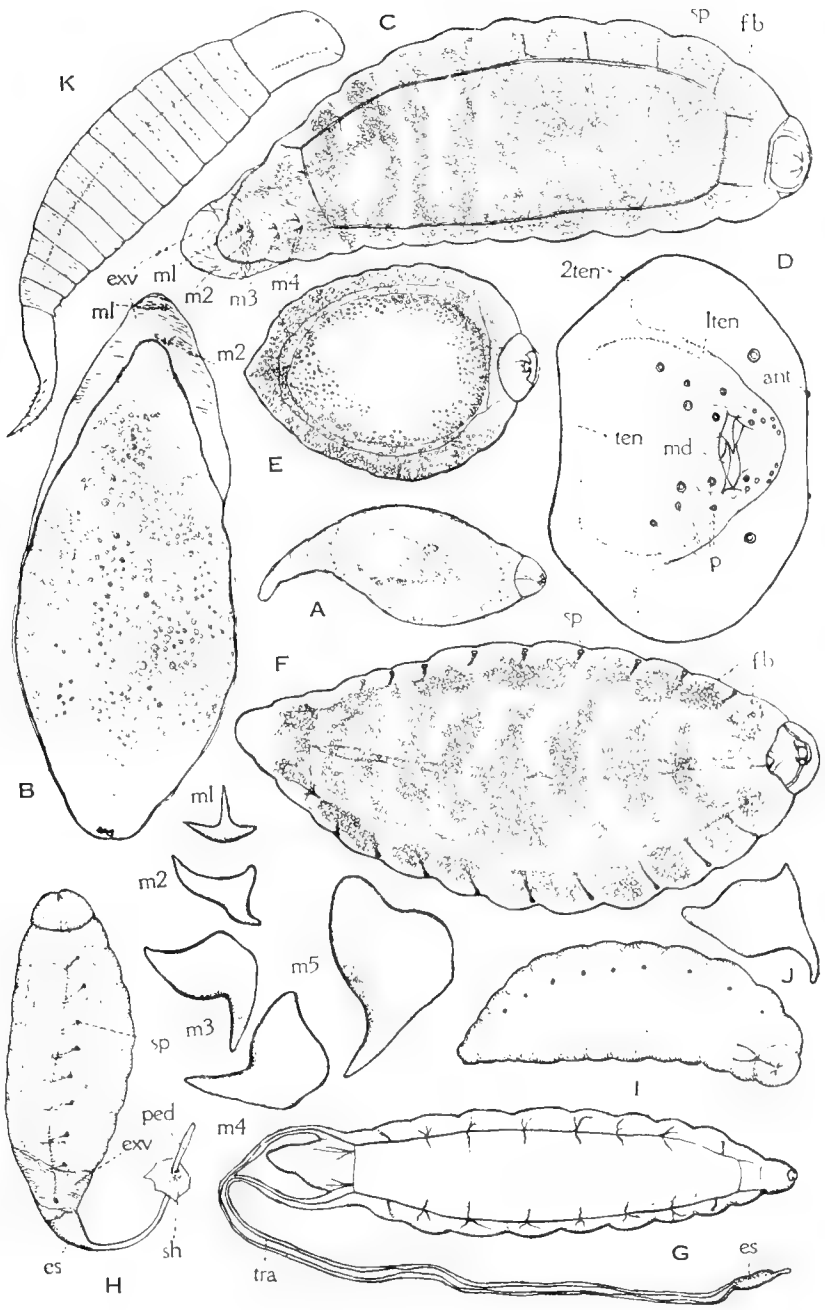




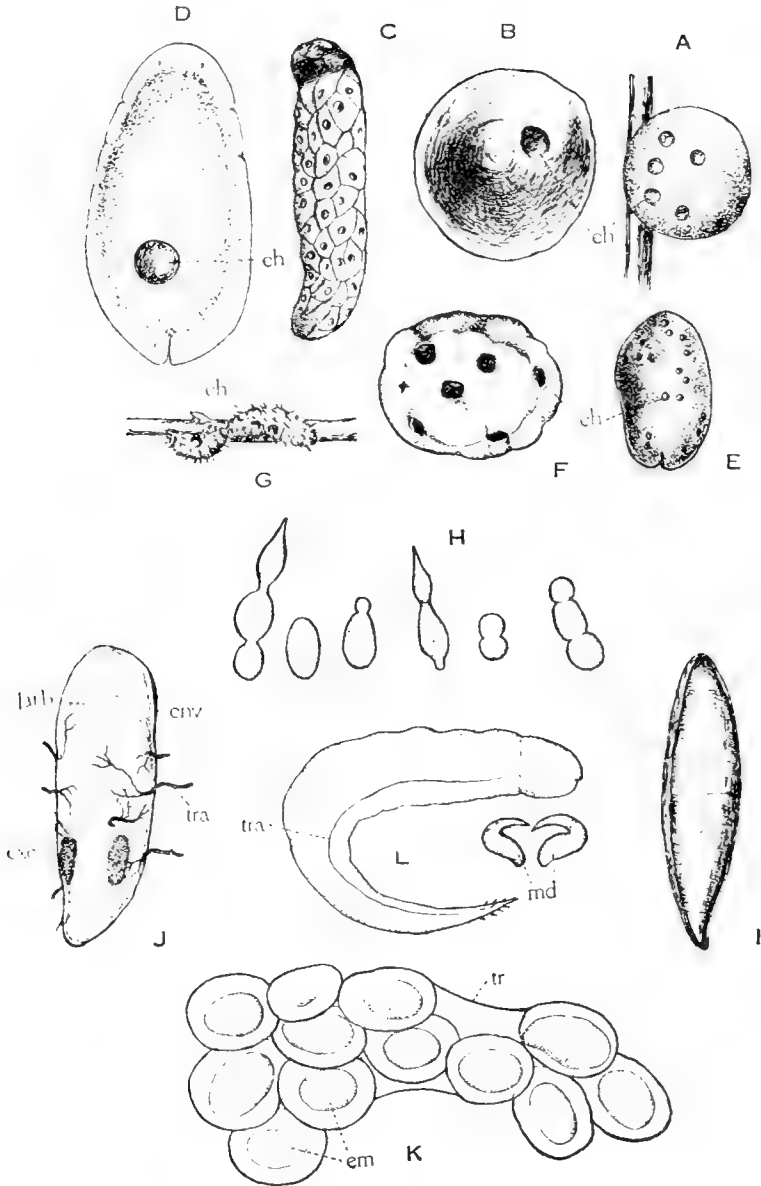














## SOME PHILIPPINE EUCHARIDS WITH NOTES ON THEIR OVIPOSITION HABITS

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Plate XI, and I Text figure.

The Eucharid-flies serving as basis for this account are those which the writer had occasion to investigate while his stay at Los Baños in the Philippines in 1929. Small as the material is, it proves to be of great interest on account of embracing two new species. Of these two one appears to represent a new genus. The species dealt with in this account are as follows:

*Parapsilogaster montanus* GIRAULT

*Kapala forcatella* GIRAULT

*Kapala violacea* n.sp.

*Losbanus uichancoi* n.g., n.sp.

Up to the present, very little has been known of the biology of the Eucharid-flies, the majority of which are parasitic on ants. In 1923 C. P. CLAUSEN put on record in some details the biology of *Shizaspidia tenuicornis* ASHMEAD which is parasitic on *Camponotus herculeanus japonicus* MAYR and deposits egg en masses within the buds of various trees. The planidia emerged from the buds gain access the nests of *Camponotus* by attaching themselves to walker ants as the latter move about the trees in search of foods, and attach themselves to host larvae. In this account a record is given of the oviposition habits of some of the above mentioned species.

Before proceeding farther, the writer wishes to express his hearty thanks to Professor L. B. UICHANCO for help rendered him during the

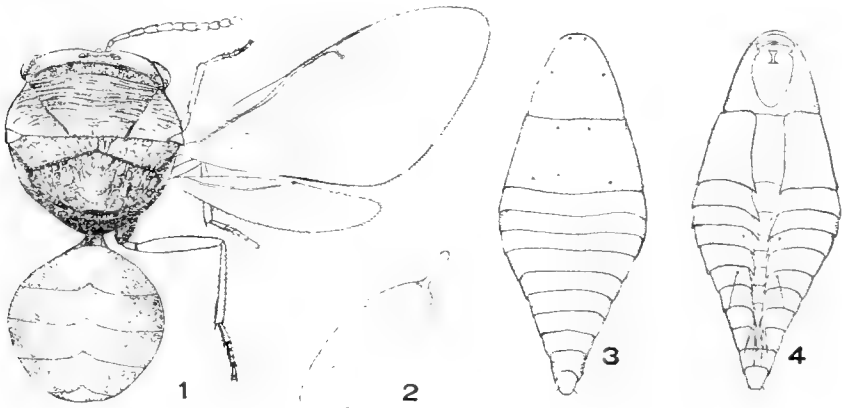
course of this work, and also to Mr. S. KINOSHITA, Professor T. KABURAKI and Mr. K. KISHIDA for kind help and advice.

### PARAPSILOGASTER MONTANUS GIRAULT

(Text fig)

Philippine Journ. Sci., Vol. 36, n. 4, p. 451, 1928.

FEMALE.—Head wider than deep (45:32), very thin in dorsal view; ocelli arranged in an obtuse-angled triangle, the lateral ocelli separated



*Parapsilogaster montanus* GIRAULT

1 Female; 2 Egg; 3 Planidium, dorsal view; 4 Same, ventral view.

from the inner eye margins by their own diameter. Mandibles long, sickle-shaped, the left with a large tooth near the middle, the right with two teeth which are subequal in size. Labrum palmate, with 6 or 9 digits, each with a spine at apex; maxillary palpi 2-jointed, the first joint elongate-cylindrical, with three bristles; the second about half the length of the first and slightly swollen in the basal half, with 3 bristles at apex; labial palpi one-jointed, very small, with one bristle at apex.

Antennae 12-jointed, measuring 1.56 mm. in length; scape rather short, spindle-shaped; and twice as long as wide; pedicel a little longer than wide; funicle joints gradually shortening distad; first joint thrice as long as wide.



Fore-wings 3 mm. long by 1.17 mm. wide; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 43:22:5:12; ciliation uniform exclusive of the basal part; apical two-thirds faintly clouded. Hind-wings 2.1 mm. long by 0.54 mm. wide; hooks three; ciliation uniform.

All legs with hairs in sparse numbers; all femora considerably thickened and broadest at the middle; tibiae rather slender; the basal joints of all the tarsi long, and those of the hind tarsi almost as long as the following three joints combined.

Abdomen visibly five-segmented, the first segment longer than the following two segments combined; all segments emarginated at the middle on the posterior margin; petiol very short, as long as the hind coxa; ovipositor slightly produced; pygidium with sparse numbers of hairs.

Head and thorax metallic blue-green with bronze and purple reflections. Antennae dark brown except the scape, pedicel and basal half of the first funicle joint which are yellowish brown; mandibles brownish red; labial and maxillary palpi pale brown. Legs yellowish except the coxae which are of the same colour as the thorax; the apices of the last tarsal joints brown. Abdomen black.

Head longitudinally striated on both sides of the face, extending from the gena upwards to the back of the anterior ocellus where the striae on both sides are connected together; a transverse keel between the posterior ocelli; occiput transversely striated.

Mesonotum transversely striated; axillae longitudinally striated; scutellum swollen conically, and strio-reticulated longitudinally; propodeum coarsely reticulated; abdomen smooth.

Body 2.7 mm. long by 1.35 mm. across at the thorax.

MALE.—Unknown.

### Egg

(Text fig. 2)

Elongate oval in shape with a short stalk at the broad end; translucent

white in colour; chorion smooth.

Length 0.18 mm. and width 0.07 mm., and length of stalk 0.04 mm.

### First Stage Larva or Planidium

(Text fig. 3, 4)

Body spindle-shape, composed of 11 segments exclusive of the head, and brown in colour except the terminal segment which is pale. Head of a considerably large size, about 0.01 mm. in length, rounded at both ends, gradually widened posteriorly; mandibles sharply pointed, crossing with each other, and occupying a position in the buccal cavity; there is a flattened chitinous plate at the middle of the lower lip; body segments subequal in length except the first which is as long as the next two joints combined. Head with two pairs of minute semitransparent round spots on the first body segment, the one near the anterior margin, the other near the posterior margin. Segments 1-8 slenderly produced posteriorly at the postero-ventral corners; eighth segment sending out a long spine on each side from the postero-ventral corner; a pair of short bristles near the tip of the last segment.

Body 0.12 mm. long by 0.04 mm. across at the widest part.

#### OVIPOSITION HABIT

This species is rather common in the district of Los Baños. The adults appear mostly in February. The female deposits eggs on the underside of the leaves of *Sandricum koctjape* and *Premna* sp. The eggs laid look like white powders scattered over the leaf. The egg stage lasts for about one week.

### KAPALA FOVEATELLA GIRAULT

(Pl. XI, Fig. 1)

Philippine Journ. Sci., Vol. 36, n. 4, p. 453, 1928.

FEMALE.—Head wider than deep (42:32); ocelli separated from the eye margins by three times their own diameter. Antennae 12-jointed,

measuring 1.38 mm. in length; scape cylindrical, about four times as long as wide; pedicel as long as wide at apex; funicle joints serrated, the scerae of joints 3-5 subequal in length and about as long as their own joints, and longer than those of others; club ovate, 2-jointed, and about as long as the last two funicle joints combined.

Fore-wings 3.3 mm. in length and 1.26 mm. in width; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 45:28:5:10; stigmal vein obscured by a fuscous cloud which forms a transverse band across the disk. Hind-wings 2.1 mm. in length and 0.54 mm. in width; hooks six.

Legs rather slender with the femora slightly thickened. First abdominal segment longer than the remaining segments combined; all the segments emarginated medially on the posterior margin; petiol slightly longer than the posterior femora.

Head and thorax metallic blue-green with bronze and purple reflections. Abdomen dark brown with faint blue-green reflections. Antennal scape and pedicel yellowish; funicle joints dark brown; mandibles yellowish brown. Legs yellowish except all the coxae which are of the same colour as the thorax.

Head smooth except the occiput which has transverse striae; mesonotum with heavy transverse striae except the parapsides which are foveate-punctated; axillae heavily striated; scutellum with some 7 striae on each side; propodeum with a few longitudinal striae at the middle; petiol longitudinally striated above; abdomen smooth. Scutellum giving off posteriorly two very long processes over the abdomen.

Body 3.6 mm. long by 1.41 mm. across at the thorax.

MALE.—Similar to female in general colour. Antennae 1.65 mm. in length; funicle pectinate, the stalk of the first much shorter than others. Face longitudinally striated on both sides of the upper parts; vertex with transverse striae. Thorax foveate-punctated above; abdomen smooth. Wings hyaline.

Body 3.3 mm. long by 1.5 mm. across at the thorax.

### Egg

(Pl. XI, Fig. 2)

Elongate oval in shape, with a long, slightly curved stalk at the broad end, translucent white in colour; chorion smooth.

Length 0.18 mm. and width 0.06 mm., and length of stalk 0.16 mm.

### First Stage Larva or Planidium

(Pl. XI, Fig. 3, 4)

Body spindle-shaped, composed of 11 segments exclusive of the head. Head 0.04 mm. long by 0.03 mm. wide, brown in colour, heavily chitinized, rounded at the anterior end, emarginated medially on the posterior margin, and widened posteriorly. Mandibles sharply pointed, crossing with each other, and lying in the buccal cavity. At the middle of the lower lip there is a flattened chitinous plate. Body segments slightly, uniformly chitinized, and pale brown in colour; first segment as long as the next two segments combined, and other segments subequal in length; segments 3-8 slenderly produced posteriorly at the postero-ventral corners; eighth segment provided on the ventral margin with a long blade-like appendage which extends beyond the terminal segment. Head with a pair of minute bristles on the anterior margin and a pair of minute semitransparent round spots in the dorsal part; first body-segment with four minute spines dorsally and one ventrally on each side; second segment without spine; third segment with two minute spines dorsally and one ventrally on each side; fourth and fifth segments with a long bristle ventrally on each side near the lateral margin, the latter segment with another short bristle a little inside of the bristle just mentioned; seventh segment with a long bristle ventrally on each side near the lateral margin; last segment with a short bristle on each side near the middle.

Body about 0.13 mm. in length and 0.05 mm. in width at the widest part.

## OVIPOSITION HABIT

This species is rather common in the district of Los Baños, and is also found by the writer at Batavia, Java, in 1928. In the former the adults, though found throughout the year, appear in the most abundance in February. The female deposits eggs in the lower tissue of the young leaves of *Griricidia sepium* and *Leucaena glauca*, making holes in the tissue by means of its ovipositor (Pl. XI, Fig. 5). Generally one to four eggs are laid in a single hole. The egg stage lasts about one week.

**KAPALA VIOLACEA** n. sp.

(Pl. XI, Fig. 11)

FEMALE.—Head wider than deep (42:32); posterior ocelli separated from the inner eye margins by four times their own diameter. Antennae 1.35 mm. in length and 11-jointed; funicle joints serrated as in *K. foveatella*, and gradually shortening distad; scape cylindrical; pedicel as long as wide at apex; first funicle joint twice as long as wide at apex; club one-jointed, short, oval in shape, and considerably longer than the last funicle joint.

Scutellum (Pl. XI, Fig. 11) sending out posteriorly two very long processes over the abdomen. Abdominal petiol considerably longer than the hind coxa; first abdominal segment much longer than the remaining segments combined; all the abdominal segments emarginated medially on the posterior margin.

Head, thorax and abdomen with blue and purple reflections; antennae with the scape and pedicel yellowish brown; funicle joints and club dark brown. Mandibles yellowish brown. Legs yellowish except all the coxae and femora, the former similar in colour to the general body-surface, the latter pale brown. Fore-wings with a brown cross stripe and faintly dusky extending from this to apex.

Head smooth; mesonotum transversely strio-reticulated; axillae and scutellum longitudinally strio-reticulated; propodeum rather smooth with two longitudinal keels along the middle line; abdomen and petiol smooth.

Body 3.3 mm. in length by 1.6 mm. across at the thorax.

MALE.—Unknown.

Type in the collection of the Imperial Agricultural Experiment Station.

REMARK.—The species is closely allied to *K. forcatella* GIRAUDT, but it may be distinguished from this by the difference in the sculpture of the thoracic notum.

**LOSBANUS UICHANCOI** n.g., n.sp.

(Pl. XI, Fig. 6)

FEMALE.—Head wider than deep (30:22), thin in dorsal aspect; ocelli arranged in an obtuse-angled triangle; the lateral ocelli separated from the inner eye margins by twice their own diameter. Mandibles long, sickle-shaped, the left with a large tooth near the middle, the right with two teeth which are subequal in size; labrum palmate with 4 digits, each with a stout spine at tip; maxillary palpi 3-jointed, the first joint cylindrical, about thrice as long as wide, the second a little shorter than the first, and the third a little shorter than the second; labial palpi one-jointed; thrice as long as wide. Antennae 11-jointed exclusive of a ring joint, measuring 1.29 mm. in length; scape cylindrical, rather short; pedicel as long as wide at apex; first funicle joint a little more than twice as long as wide, the second a little shorter than the first, the third almost as long as the second, the following joints, except the last, subequal in length and width, and slightly longer than wide, and the last joint as long as the preceding two joints combined.

Fore-wings 2.25 mm. in length and 0.96 mm. in width; submarginal, marginal, stigmal and postmarginal veins approximately in the ratio of 32:20:2:10; ciliation uniform except the basal part; apical two thirds faintly clouded; veins brown. Hind-wings 1.8 mm. in length and 0.39 mm. in width; hooks three; ciliation uniform.

Legs slender; the first tarsal joint of the hind legs as long as the following three joints combined.

The first abdominal segment as long as about half the length of the

abdomen; petiol cylindrical, and slightly longer than the hind femur.

Head and thorax metallic-green; pleurae, metanotum and propodeum with blue and purple reflections; abdomen black with slight blue and purple reflections. Antennae with the scape yellowish brown, pedicel pale brown; flagellum dark brown; mandibles yellow except the tip which is brown. Legs yellowish except all the coxae which are similar in colour to the thorax.

Head and thorax foveate-reticulated except the parapsides which are smooth and shining; parapsidal furrows and the furrows between the axillae and scutellum foveate; scutellum with a transverse keel near the tip.

Body 2.8 mm. in length and 0.66 mm. in width at the thorax.

MALE.—Unknown.

Types in the collection of the Imperial Agricultural experiment Station.

REMARK.—The present form is closely allied to *Parapsilogaster* GIRAULT, but it may be distinguished from this by the following points:—Maxillary palpi 3-jointed (2-jointed in *Parapsilogaster*); thorax much longer than wide; parapsides and axillae somewhat swollen and smooth; scutellum not particularly swollen; abdominal petiol elongate-cylindrical; abdominal segments with the posterior margin not emarginated.

### Egg

(Pl. XI, Fig. 7)

Elongate ovoid in shape, with a rather long stalk at the broad end; translucent white, and chorion smooth. Length 0.14 mm., width 0.05 mm., and length of stalk 0.08 mm.

### First Stage Larva or Planidium

(Pl. XI, Fig. 8, 9)

Body spindle-shaped composed of 11 segments exclusive of head, pale brown in head, and brownish in body. Head rather small as compared with the preceding species, measuring 0.03 mm. in length, and a little longer than wide; mandibles sharply pointed, crossing with each other.

and lying in the buccal cavity; two pairs of minute semitransparent round spots in the head, the one near the anterior margin; the other near the middle. First body-segment as long as the following two segments combined; second a little longer than the third; other segments subequal in length; two pairs of minute semitransparent round spots on the dorsal side of the first segment, the one near the anterior margin, the other near the posterior margin; a pair of similar spots near the posterior margin of the second segment. Eighth segment slenderly produced posteriorly from the postero-ventral corners; a small bristle on each side of the last segment near the middle.

Length about 0.16 mm., and width 0.052 mm. at the widest part.

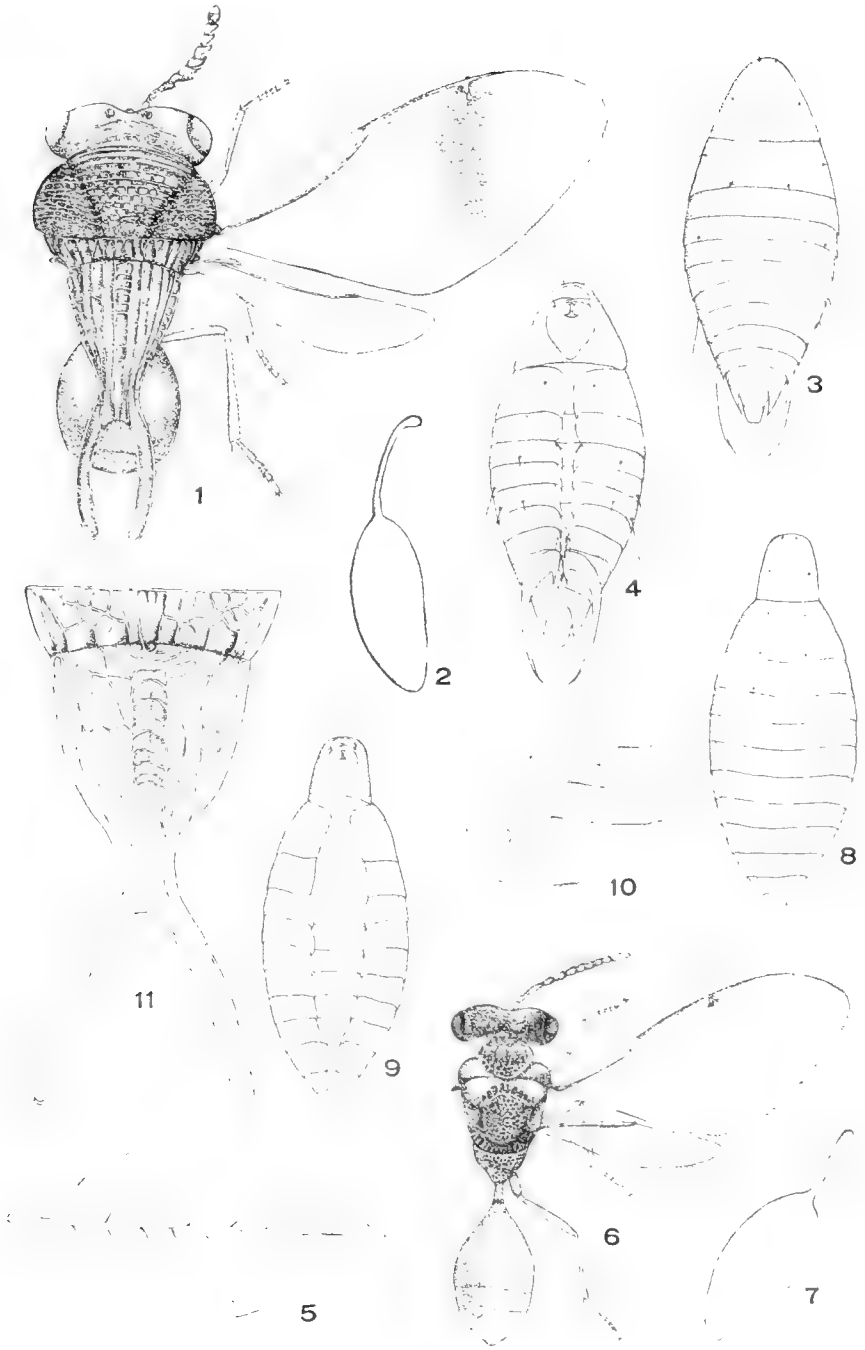
#### OVIPOSITION HABIT

In the district of Los Baños, this species may be collected throughout the year. However, the adults are most common during the dry season, especially in February. The female deposits eggs in the lower tissue of the young leaves of *Celtis philippinensis* and *Leucaena glauca*, making holes by means of its ovipositor. The holes are arranged in two short parallel rows as is shown in the accompanying figures (Pl. XI, Fig. 10). The duration of the egg stage seems to be about one week.

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TEMPERATURE CHARACTERISTICS OF PULSATION AND  
GROWTH IN MOSQUITOE PUPAE, AS BASIS FOR  
DETERMINATION OF LOWER DEVELOP-  
MENTAL THRESHOLD POINT.

Nobumasa YAGI, D.Sc.

With regard to the determination of the total effective temperature of insects there is a difference of method. On account of impossibility of calculating the said temperature without knowing the threshold temperature of development a number of workers make use of Blunk's<sup>1)</sup> formula which is regarded as corresponding to the equilateral hyperbola compiled by plotting the periods of development and the respective temperatures. However, the threshold point determined by means of this formula is no more than hypothetical, because of the fact that the velocity of development varies to a certain extent either at a low or at a high temperature, differing from that at the range of optimum temperatures, as pointed out by Krogh.<sup>2)</sup>

Further Krafka's<sup>3)</sup> exponential formula based upon the development of *Drosophila melanogaster* larva and Janisch's<sup>4)</sup> generalized exponential curves appear, to the author's mind, to be of no value for the determination of the threshold temperature from a physiological basis. So far as the author can learn, nothing is known of physiological factors limiting the development at a low temperature, exclusive the case with larva of *Potosia cuprea* which is, according to Werner,<sup>5)</sup> capable of digesting cellulose by the action of Bacteria. In this case the larva does not grow altogether at temperatures below 10°C., a minimum temperature for the fermentation of cellulose.

Some times ago an attempt was undertaken to study the development of mosquito pupae at various constant temperatures. Taking the results

obtained into consideration, the author thinks it advisable to apply the critical point of temperature characteristics of pulsation as basis for the determination of the threshold temperature.

In discussion of the use of the critical thermal increment (of Arrhenius) for the characterization of biological processes whose velocities are a function of temperature Crozier<sup>6,8)</sup> has pointed out that in the case of oxidative phenomena critical increments of orders 11500 and 16700 are repeatedly encountered. As reason for the occurrence of increments in connection with tissue respiration, one on either side of some median temperature (usually found to be near 15°C), it was suggested that at least two processes might be concerned in biological oxidations. Further, from a consideration of measurements recorded hitherto, it was shown that organic activities provide critical increments very similar to those given for oxidative phenomena. However, it was made out that the critical increments for oxygen utilization and for CO<sub>2</sub> production do not appear to be characteristic for measurements of growth in animal and plants (eggs of *Arbacia*, radicle of *Pisum*, etc.).

So far as the author's experiments are concerned, the temperature characteristics of development of the pupae of *Aedes togoi* are 18500 at temperatures lower than 15°C and 9200 at those higher than this, as shown in Table 1 and Fig. 1. These values are not exactly the same as those determined in oxidative phenomena but are very close to them. On the other hand, the temperature characteristics of the heart beat in the pupae are 15200 at temperature below 15°C and 6450 at those above this, as shown in Table 2 and Fig. 2. These values, according to Crozier's assumption, are of oxidative significance.

Although development is regarded as consisting of several different processes and their temperature characteristics are not enough to limit at once their intracellular chemical process, yet the agreement of the lower critical points of temperature characteristics of heart beat and development in this insect is of some significance to suggest the similarity of certain underlying chemical process.

TABLE 1.  
Development of the pupa of *Aedes togoi*.

Temp. in °C	Time required	Relative velocity (1000/time)	Log of velocity	1/Tabs. × 10 <sup>4</sup>	Temperature characteristics
8	196,5 hr.	5,10	0,71	35,6 . . .	} μ = 18500
12	122	8,20	0,91	35,1	
16	78	12,80	1,11	34,6 . . .	
20	64	15,63	1,19	34,1 . . .	} μ = 9220
24	53	18,87	1,28	33,7	
28	43	23,26	1,37	33,2 . . .	
32	44	22,73	1,36	32,8	
33	46	21,74	1,34	32,74	

TABLE 2.  
Heart beat in the pupa of *Aedes togoi*.

Temp. in °C	No. of heart beat in a minute	Log of number of heart beat	1/Tabs. × 10 <sup>5</sup>	Temperature characteristics
4	stop			
6	stop			
8	25,3	1,40	356 . . .	} μ = 15200
11	32,8	1,52	352	
13	40,5	1,61	349	
15	45,2	1,66	347 . . .	
16	46,7	1,67	346 . . .	
18	50,8	1,71	344	} μ = 6450
19	54,0	1,73	342	
21	58,5	1,77	340	
25	65,3	1,82	336	
29	74,3	1,87	331	
32	85,0	1,93	328 . . .	
35	103,9	2,02	325	
36	128,1	2,11	324	
37	140,0	2,15	323	
38	120,0	2,08	321	
39	107,6	2,03	320	

μ is calculated from the equation of Arrhenius,  $\frac{K_1}{K_2} = e^{\mu (\frac{1}{T_1} - \frac{1}{T_2})}$ .

Critical increments are of different orders at temperatures greater than 28° and 32°C in development and heart beat respectively.

In fact the heart beat is inaugurated in the pupae at about 8°C, inducing their development. Accordingly the lower developmental thresh-

Fig. I

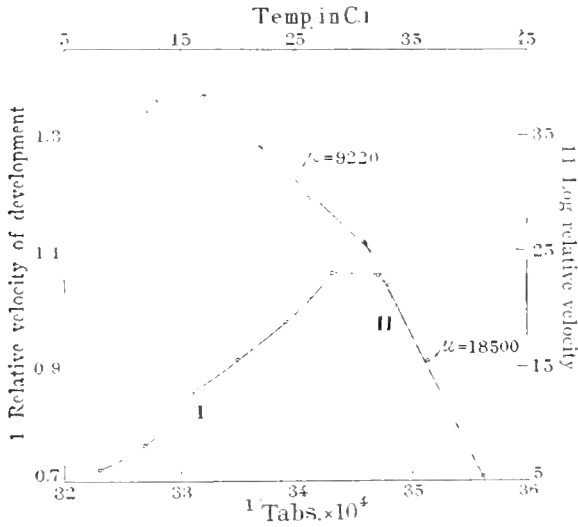
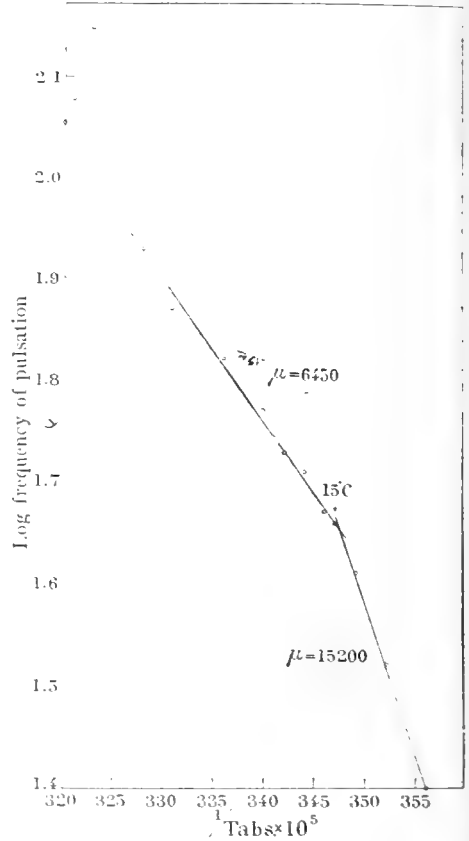
Development of the pupa of *Aedes togoi*.

Fig. II

Heart beat in the pupa of *Aedes togoi*.

old point may be practically determined through observation of temperature which stands between two point effective and non-effective for check of normal heart beat.

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ZUR KENNTNIS DER PERISTALTISCHEN BEWEGUNG  
VON *CHILO SIMPLEX* BUTLER IN IHRER ABHAEN-  
IGKEIT VON DER TEMPERATUR

Kaduhusa MISAKA

Tafel XII-XIV und zwei Textfiguren

Für die Bekämpfung der Vorratsschädlingen wird im allgemeinen die Vergasung im fest verschlossenen Zimmer ausgeführt. Diese Methode ist aber nicht ganz einwandfrei, was davon herrührt, dass wir noch keine genaue Untersuchungen über das Vergasungsmittel ausgeführt haben, um z. B. ihre Art und Gebrauchsmenge usw. näher kennen zu lernen. Bei der praktischen Anwendung des Vergasungsmittels ist es unbedingt nötig, dass wir genaues Kenntnis über die physikalisch-chemische Eigenschaft und die pharmakologische Wirkung dieses Mittels, sowie ihr physiologische Verhalten im Insektenkörper bei der Vergasung haben. Bevor solche Untersuchungen zur Ausführung ankommen werden, beabsichtigt der Autor zunächst über die peristaltische Bewegung der Larven bei verschiedenen Temperaturen näher zu erforschen, um die Grundlage der Vergasungsuntersuchung gegen die im Stroh überwinternden Larven von *Chilo simplex* zu bekommen.

Eine eingehende Beschreibung der Untersuchungsmethode war schon in Jour. Coll. Agr. Imp. Univ. of Tokyo Vol. X, No. 1 veröffentlicht, wobei grosse Aufmerksamkeit auf die Messung der Temperatur des Insektenkörpers gerichtet wurde. Nach YAGI erreicht die Körpertemperatur des Insekts, welches von einem gewissen Gegend zu einem anderen mitgebracht wird, um eine halbe Stunde beinahe den gleichen Grad wie im letzteren

und je grösser die Differenz zwischen die Körper- und die Aussenwelts-temperatur ist, desto kürzer wird die Zeit zum Ausgleichen der beiden Temperaturen sein. Beim ersten Versuche haben wir die Bewegungsfrequenz um ungefähr 20-30 Minuten nach dem Anfange des Versuchs zu studieren begonnen.

### PERISTALTISCHE BEWEGUNG BEI VERSCHIEDENEN TEMPERATUREN.

Die Bewegungsfrequenz zwischen  $-10^{\circ}$  und  $45^{\circ}$  Temperatur wird bei 19 Arten bezahlt und ihr Mittelwert für jede Temperatur in der folgenden Tabelle gezeigt: je höher die Temperatur ist, desto grösser wird die Bewegungsfrequenz, mit Ausnahme von über  $41^{\circ}$ . Zwischen  $-10^{\circ}$

Tabelle I. Bewegungsfrequenz bei verschiedenen Temperaturen

Temperatur	$40^{\circ}$	$35^{\circ}$	$30^{\circ}$	$25^{\circ}$	$20^{\circ}$	$15^{\circ}$	$10^{\circ}$	$5^{\circ}$	$0^{\circ}$	$-5^{\circ}$	$-10^{\circ}$
Bewegungsfrequenz pro Minute	19.9	9.4	4.5	3.1	1.9	1	0.4	0.1	0	0	0

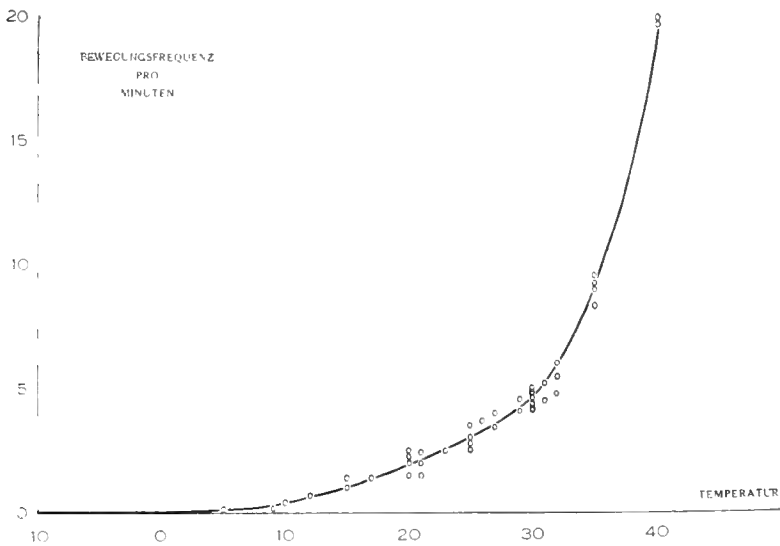
und  $0^{\circ}$  geschieht keine Bewegung, und erst bei  $5^{\circ}$  beginnt eine kräftige (vgl. Tafel XII. 6, 7, 8, 9). Bei  $10^{\circ}$  und  $17^{\circ}$  nimmt man die kräftige Bewegung wahr, die sehr unregelmässig verläuft (vgl. Tafel XII. 4, 5). Zwischen  $35^{\circ}$  und  $40^{\circ}$  erreicht die Bewegung das Maximum (vgl. Tafel XIII. 5, 6) und über  $41^{\circ}$  kommen viele kleine Zuckungen zum Vorschein, was die Messung der Bewegungsfrequenz schwierig macht. Ueber  $41^{\circ}$  sieht man die Verkleinerung der Bewegung und die Verminderung ihrer Frequenz, deren Kurve bei  $45^{\circ}$  immer kleiner und weniger wird (vgl. Tafel XIII. 1, 2, 3, 4).

Wenn man als Ordinate die Zahl der rhythmischen Bewegungen pro Minute und als Abszisse die Temperaturgrade nimmt, haben wir eine Kurve, welche das Verhältnis zwischen diesen beiden zeigt, von welcher der sogenannte Temperaturkoeffizient von VAN'T HOFF wie folgt ausgerechnet wird:



$$Q_{10}=3.1 (15^{\circ}-25^{\circ}) \quad Q_{10}=2.42 (20^{\circ}-30^{\circ}) \quad Q_{10}=3.03 (25^{\circ}-35^{\circ}).$$

Die obengeschilderte Abhängigkeit der peristaltischen Bewegung von der Temperatur lässt sich beinahe mit dem, was wir bei der Herzschlagfrequenz der Katze (nach SNYDER) sehen, in einer Uebereinstimmung bringen. Denselben Typ der Beziehung zwischen der Temperatur und der Frequenz sieht man beim dorsalen Blutgefäße des marinen Wurms *Nereis virens* nach ROGOER, ebenso bei der Herzschlagfrequenz des Krebses *Ceriodaphnia* nach ROBERTSON und Schildkrötenherzens *Emys europaea* nach GALEOTTI und PICCININI usw. Wir waren nicht in der Lage, genau die Bewegungsfrequenz über 40° zu messen, wie man oben gesehen hat; wir haben gesehen, dass über 40° die Bewegungsfrequenz allmählich mit der Temperatursteigerung abzunehmen beginnt.

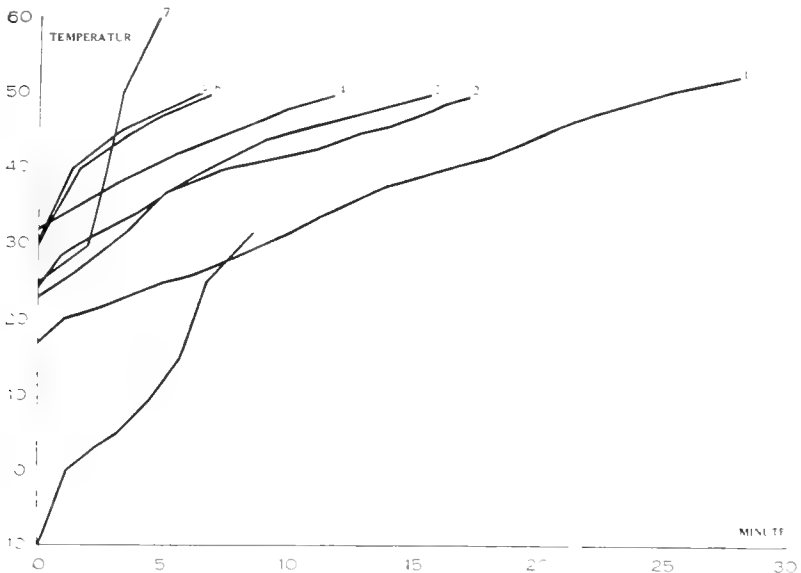


Textfigur 1. Die Temperaturabhängigkeit der peristaltischen Bewegung von *Chilo simplex* BUTLER.

### EINFLUSS DER DAUERNDEN STEIGERUNG DER TEMPERATUR.

Versuch 1. (Tafel XIV. 1) Bei diesem Versuche wird die Tem-

peratur von  $17^{\circ}$  bis zu  $35^{\circ}$  während der Zeitdauer von etwa 28 Minuten gesteigert und diese Reizkurve ist in Textfigur II. 1 dargestellt. Je höher die Temperatur wird, desto lebhafter wird die rhythmische Bewegung, deren Kurve zwischen  $36^{\circ}$  und  $41^{\circ}$  sehr regelmässig ist, aber über  $41^{\circ}$  allmählich schwächer und kleiner wird, und zwar mit unregelmässiger Zuckung. Bei  $48^{\circ}$  können wir nur sehr kleine Bewegungen und endlich über  $50^{\circ}$  gar keine beobachten, zu welcher Zeit der Insektenkörper sich verlängert und die Kurve fällt ab.



Textfigur II. Die Reizkurve bei der Temperatursteigerung.

Versuch 2. (Tafel XIV. 2) Die Temperatursteigerung von  $23^{\circ}$  bis zu  $50^{\circ}$  fand während der Zeitdauer von 17.2 Minuten statt und diese Reizkurve sieht man in Textfigur II. 2. Auch in diesem Versuche kommt die unregelmässige Zuckung über  $41^{\circ}$  zum Vorschein und bei  $48^{\circ}$  kommt die verkleinernde Bewegung zum Verschwinden.

Versuch 3. (Tafel XIV. 3) In diesem Versuche wird die Temperatur von  $24^{\circ}$  bis zum  $50^{\circ}$  während der Zeitdauer von 15.6 Minuten gesteigert und diese Reizkurve ist in Textfigur II. 3 dargestellt. Die rhythmische Bewegung wird allmählich lebhafter, aber über  $40^{\circ}$  kleiner

und schwächer mit unregelmässiger Zuckung, um schliesslich bei  $48.5^{\circ}$  zu verschwinden.

Versuch 4. (Tafel XIV. 4) Während der Zeitdauer von 11.7 Minuten lang wurde die Temperatur von  $32^{\circ}$  bis zum  $50^{\circ}$  gesteigert, deren Reizkurve in Textfigur II. 4 dargestellt ist. Der Verlauf der Bewegung gleicht gänzlich dem beim vorigen Versuche: über  $41^{\circ}$  nimmt man viele Zuckungen wahr und die Bewegung ist unregelmässig. Nach und nach verlängert sich der Insektenkörper, der über  $48^{\circ}$  unbeweglich ist.

Versuch 5. & 6. (Tafel XIV. 5 & 6) Bei diesen Versuchen ist die Temperatursteigerung ( $30^{\circ}$ – $50^{\circ}$ ) etwas plötzlicher als beim vorigen, denn jene braucht 6.4 Minuten und diese 6.8. Bei diesem Reiz tritt die unregelmässige Zuckung sofort nach dem Anfang des Versuchs ein, und die Kurve geht mit der Verlängerung des Insektenkörpers herunter. Die Temperatur des Bewegungsstillstandes ist niedriger ( $46.5^{\circ}$  und  $43.5^{\circ}$ ) als beim vorigen Versuche.

Versuch 7. (Tafel XIV. 7) Die Temperatursteigerung von  $25^{\circ}$  bis zum  $60^{\circ}$  fand während 4.7 Minuten statt und Textfigur II.7 zeigt diesen Reiz, der am stärksten unter diesen Untersuchungen zu betrachten ist. Der Insektenkörper wird durch diesen starken Reiz allmählich gelähmt; wobei wir nur wenige Zuckungen sehen, welche schon bei  $40^{\circ}$  zum Stillstand kommen.

Versuch 8. (Tafel XIV. 8) Bei der plötzlichen Steigerung von der niedrigen Temperatur ( $-10^{\circ}$  zu  $32^{\circ}$ ) können wir keine rhythmische Bewegung wahrnehmen, indem Insektenkörper sich allmählich verlängert und bald wieder ohne Zuckung kürzer wird. Ueber  $25^{\circ}$  steht er still, denn er war durch stärkeren Reiz gelähmt worden.

Im allgemeinen wird die peristaltische Bewegung der Larve durch die Temperatursteigerung lebhafter, doch bei der noch höheren Temperatur schwächer mit der Zuckung und endlich stellt sich nach der Verlängerung des Körpers ein. Das Verhältnis zwischen der Reizgeschwindigkeit und dem Verlauf der peristaltischen Bewegung ist klar aus der Tabelle II zu sehen; je schneller der Reiz wirkt, desto früher, d.h. unter desto niedriger

Tabelle II. Verlauf der peristaltischen Bewegung bei jeden Reiz.

Beim Versuche	I	II	III	IV	V	VI	VII
Temperatur							
Lebhafte Bewegung	36°	37°	34°	38°	35°	33°	28°
Schwache Bewegung	41°	41°	40°	40°	35°	33°	30°
Erscheinung der Zuckung	41°	41°	41°	41°	35°	35°	30°
Einstellung der Bewegung	50°	48°	48.5°	48°	46.5°	43.5°	40°

Temperatur, tritt ein Bewegungsverlauf auf. Durch die Temperatursteigerung der Aussenwelt kann die Bewegung wieder beginnen, welche bei niederer Temperatur still gestanden war, aber trotz der Erniedrigung der Temperatur wird die Bewegung nicht wiederholt, welche bei höherer Temperatur zu Stillstand gebracht war.

#### ZUSAMMENFASSUNG

Die peristaltische Bewegung der Larve von *Chilo simplex* BUTLER wird von der Temperatur der Aussenwelt beeinflusst: je höher sie wird, desto mehr wird die Bewegungsfrequenz, welche bei 40° das Maximum erreicht und dann über 40° die Neigung hat, mit der Temperatursteigerung allmählich abzunehmen. Ueber diese Frequenz bei verschiedenen Temperaturen ist  $Q_{10}$  wie nachfolgt.

$$Q_{10}=3.1 (15^{\circ}-25^{\circ}) \quad Q_{10}=2.42 (20^{\circ}-30^{\circ}) \quad Q_{10}=3.03 (25^{\circ}-35^{\circ})$$

Durch die Temperatursteigerung wird die peristaltische Bewegung immer schwächer, indem unregelmässige Zuckungen zum Vorschein kommen. Der Insektenkörper, welcher durch Lähmung sich verlängert, wird endlich unbeweglich. Dieser Verlauf wird von der Geschwindigkeit des Temperaturreizes beträchtlich beeinflusst: je schneller der Reiz eintritt, desto früher, d.h. unter desto niederer Temperatur, tritt ein Bewegungsverlauf auf. Und durch die Temperatursteigerung der Aussenwelt kann die Bewegung wieder beginnen, welche bei niederer Temperatur still gestanden war, aber trotz der Erniedrigung der Temperatur wird die Bewe-

gung nicht wiederholt, welche bei höherer Temperatur zu Stillstand gebracht war.

Am Ende dieser Schrift schulde ich den Herrn S. KINOSHITA, Direktor der entomologischen Abteilung, und Dr. N. YAGI besonderen Dank für ihre freundliche Leitung bei dieser Arbeit.

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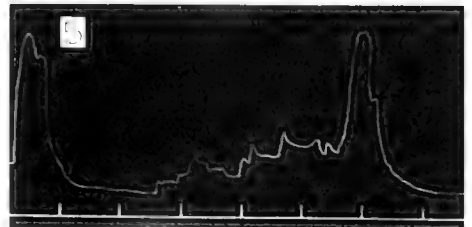
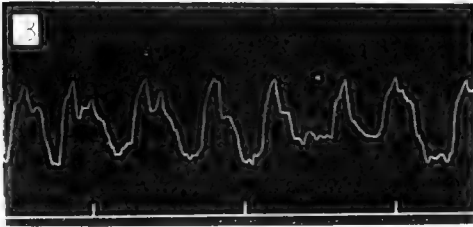
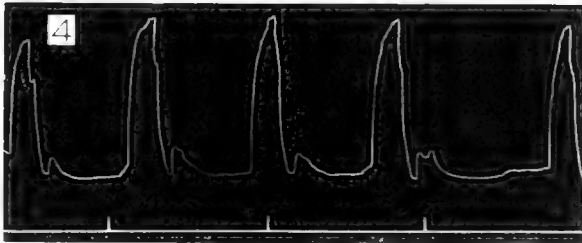
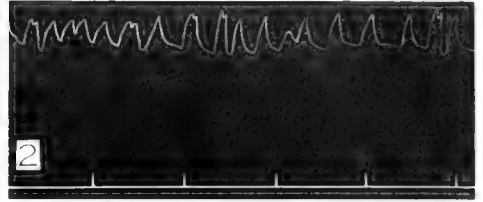
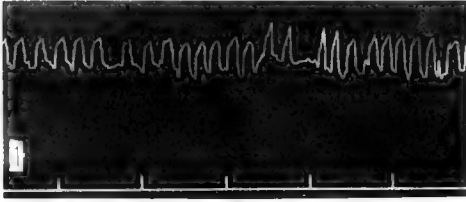
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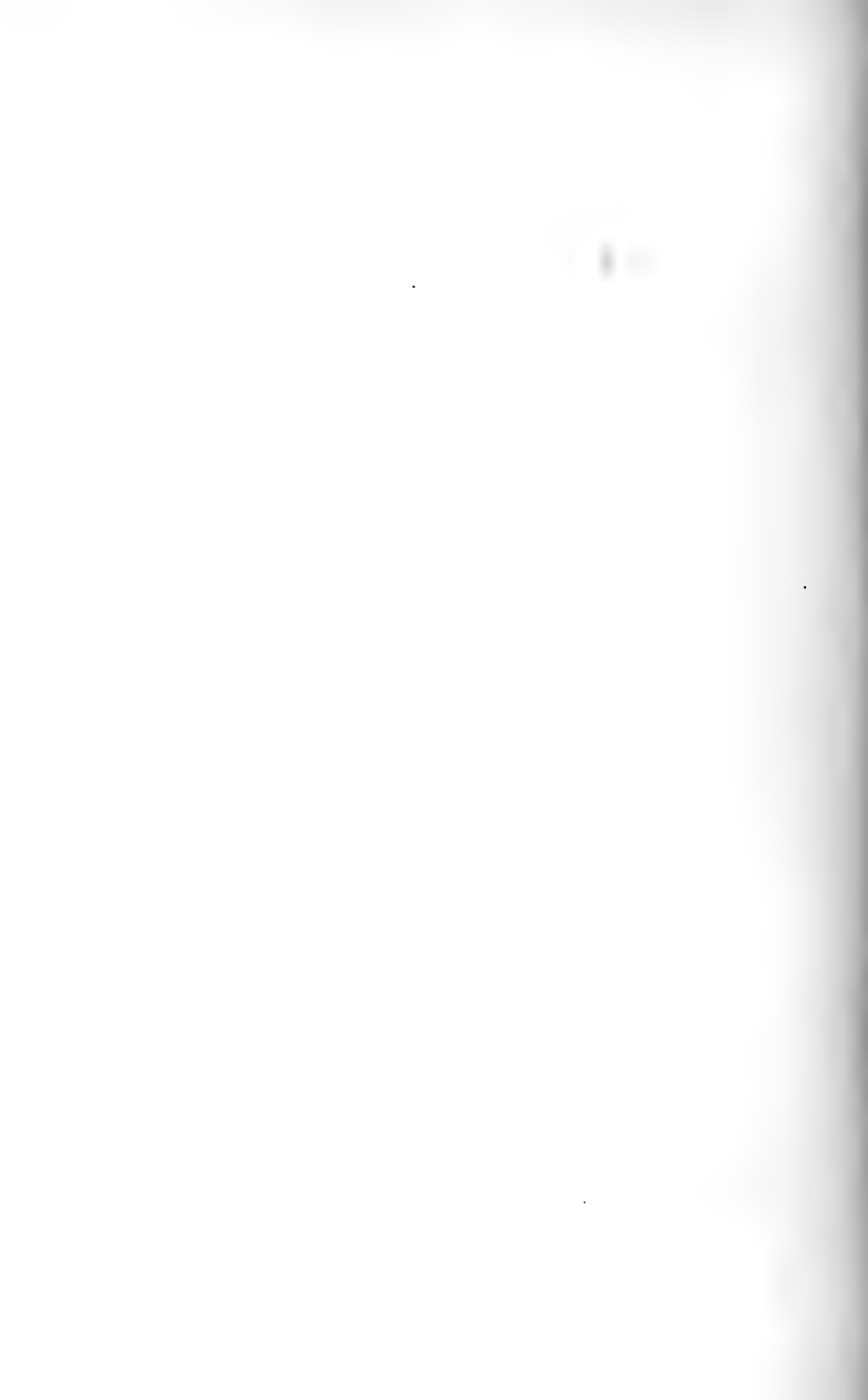
## TAFELERKLÄRUNG

Tafel XII. Peristaltische Bewegung bei  $27^{\circ}$  (1),  $25^{\circ}$  (2),  $20^{\circ}$  (3),  $17^{\circ}$  (4),  $10^{\circ}$  (5),  $5^{\circ}$  (6),  $0^{\circ}$  (7),  $-5^{\circ}$  (8) und  $-10^{\circ}$  (9). Jedes Intervall der Abszisse entspricht je eine Minute.

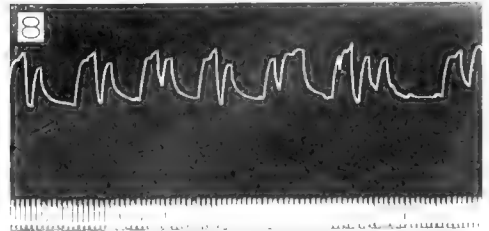
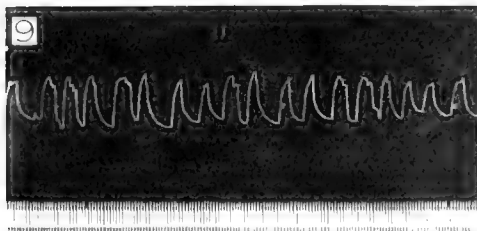
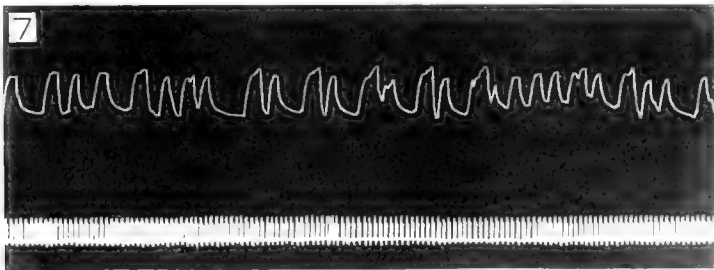
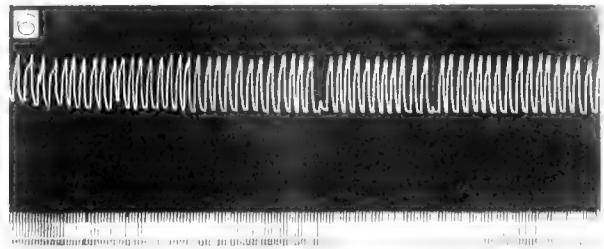
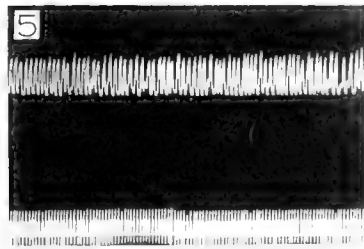
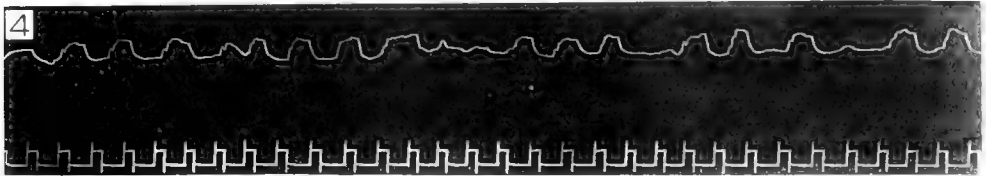
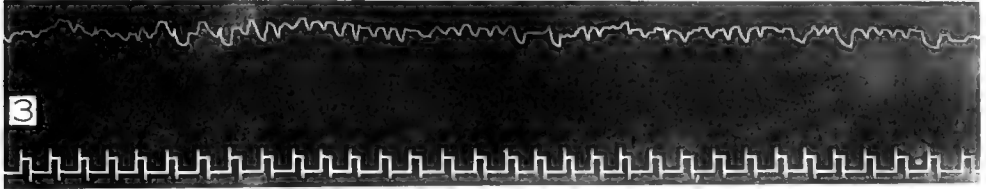
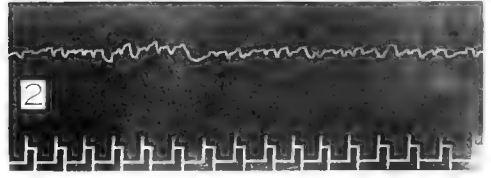
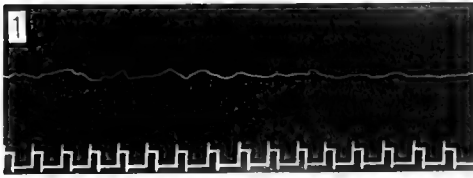
Tafel XIII. Dieselbe bei  $45^{\circ}$  (1),  $43^{\circ}$  (2),  $42^{\circ}$  (3),  $41^{\circ}$  (4),  $40^{\circ}$  (5),  $35^{\circ}$  (6),  $32^{\circ}$  (7),  $31^{\circ}$  (8) und  $30^{\circ}$  (9). Jedes Intervall der Abszisse entspricht je zwei Sekunden.

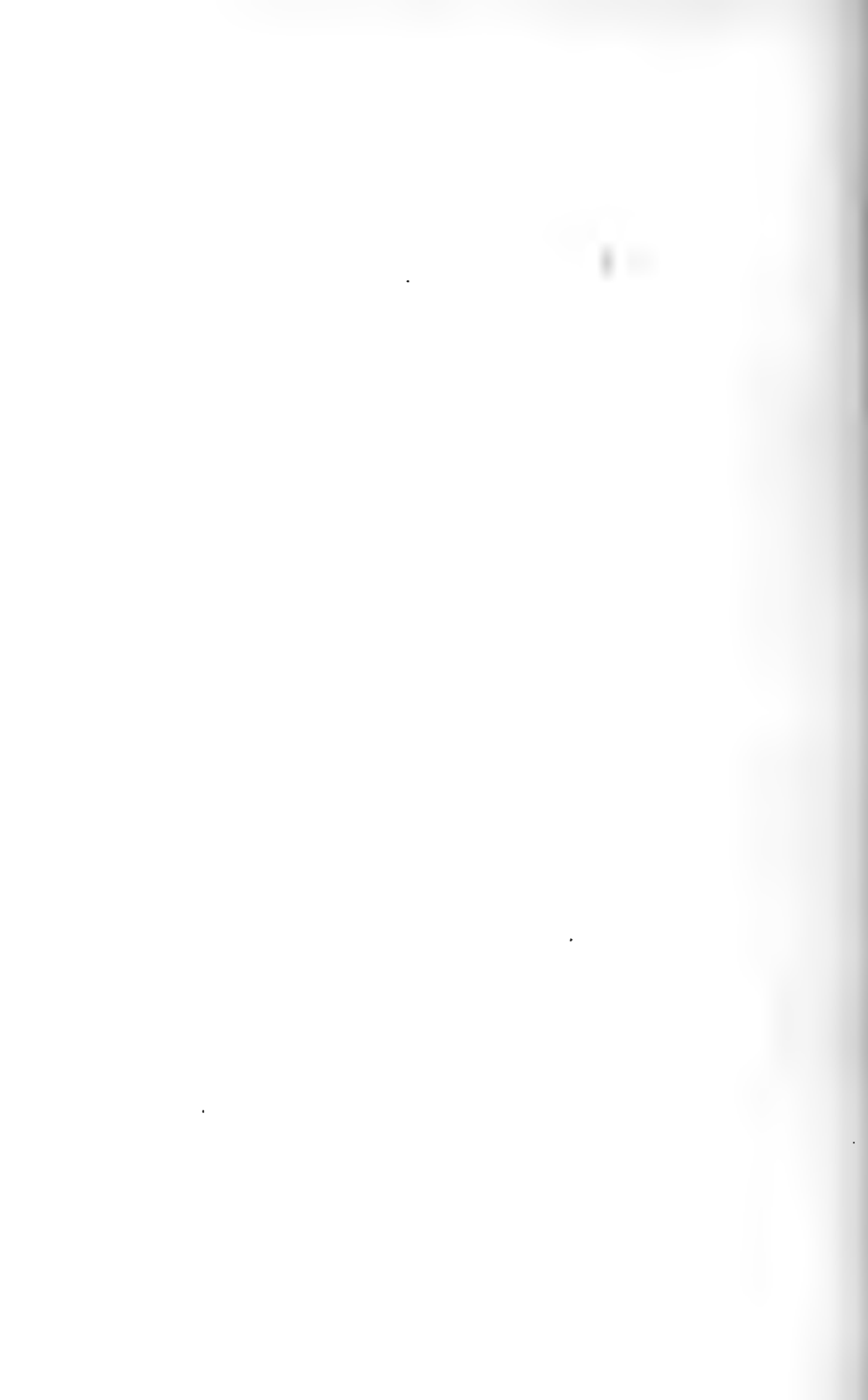
Tafel XIV. Verlauf der peristaltischen Bewegung bei langsamer (1, 2), etwas schneller (3, 4), sehr schneller (5, 6) und plötzlicher (7) Temperatursteigerung. Derselbe bei Steigerung von niederer Temperatur (8). Jedes Intervall der Abszisse entspricht je zwei Sekunden und die Ziffern bedeuten die Temperatur der Aussenwelt.

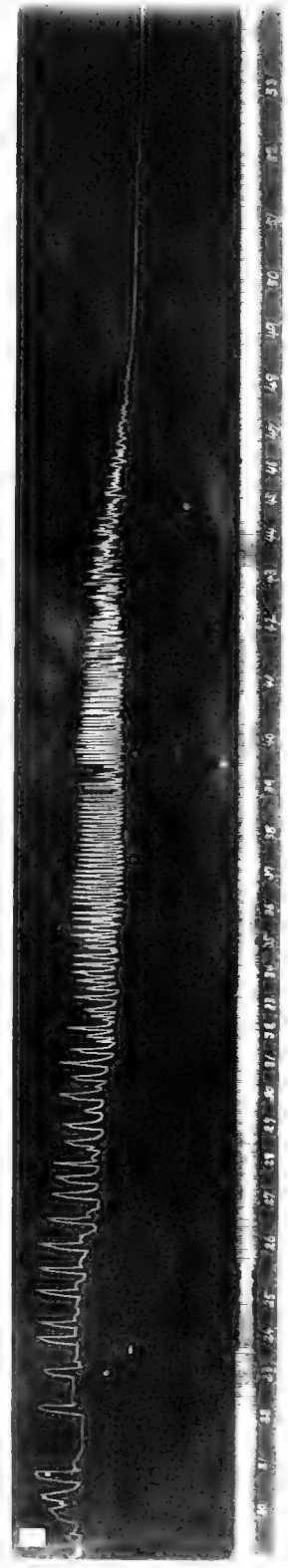
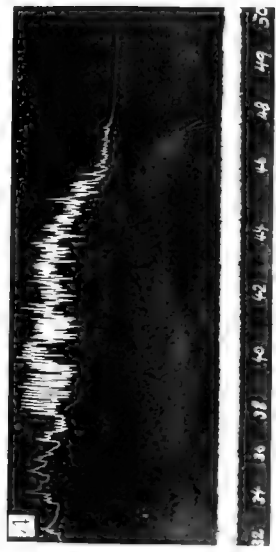
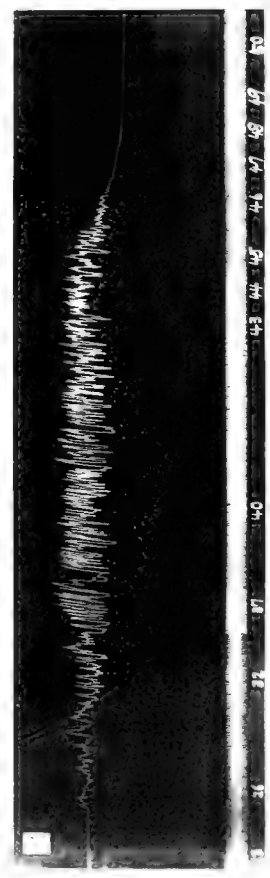
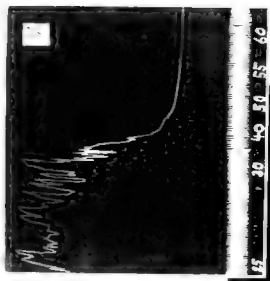
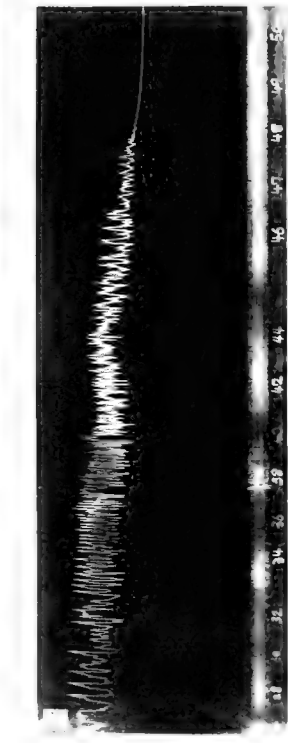














UEBER DIE WIRKUNG DES NIKOTINSULFATES  
AUF DIE EMBRYONALENTWICKLUNG  
VON *CHILO SIMPLEX* BUTLER

Kaduhusa MISAKA

Tafel XV und vierzehn Textfiguren

INHALTSVERZEICHNIS

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EINLEITUNG

Bei uns ist es wohl bekannt, dass *Chilo simplex* BUTLER ein furchtbar schädliches Insekt für Reispflanzen ist, sodass seit alter Zeit seine Bekämpfung von vielen untersucht worden ist und dementsprechend heute verschiedene physikalische, chemische und biologische (die Verwendung des Naturfeindes) Methode dafür im Gebrauch sind. Dessenungeachtet haben wir noch keine vollkommen inwandfreie Bekämpfungsmethode, was weitere Untersuchung benötigen dürfte. Die Gegenstände der bisherigen Methode sind hauptsächlich die Falter und Raupen dieses Schädlings; die Bewegungsgrenze jener ist sehr weit und auch diese dringen nach der Ausbrütung sofort in den Pflanzenkörper ein, sodass unsere Bekämpfungs-

methode sehr kompliziert ist und keinen guten Erfolg gibt. Da bei der Eierperiode, d. h. der Ruhezeit der Insekten, wir mit grossem Effekt die Schädlinge bekämpfen können, ohne ihre Verbreitung zu befruchten, habe ich genaue Untersuchung über Eierabtötung von *Chilo simplex* zu machen beabsichtigt und vor allem studiert, wie das Nikotinsulfat auf die Embryonalentwicklung der Schädlingseier einwirken wird.

Es ist meine angenehme Pflicht, hier Herrn S. KINOSHITA, Direktor der entomologischen Abteilung, und Dr. N. YAGI meinen besten Dank für ihre freundliche Leitung abzustatten. Herr T. ONOE hat mir bei dieser Arbeit stets viele wertvolle Winke gegeben und sich die Mühe der Verfertigung und Analyse des Bekämpfungsmittels gemacht, wofür ich hier meinen herzlichen Dank äussere. Auch Herrn Prof. Dr. T. KABURAKI an der kaiserlichen Universität zu Tokyo spreche ich für seine wertvolle Anregung und freundliche Verleihung der Literatur meinen grossen Dank aus. Und besonderen Dank schulde ich Herrn Prof. Dr. S. IKENO für seine freundliche Leitung beim Berichte dieser Untersuchung.

#### MATERIAL UND METHODE

*Chilo simplex*, das von den landwirtschaftlichen Versuchsstationen zu Tōkyō, Hukui, Ehime und Aiti gesandt worden ist, habe ich im Experimentzimmer gezüchtet, um die Eier auslegen zu lassen. Bei der Anwendung wird das folgende sechs Arten Bekämpfungsmittel der Nikotinlösung gemacht. Und besonders beim Experimente mit Nikotینگase ist die Menge des reinen Nikotins pro Liter wie folgt: 1) 0.2836 mg. 2)

TABELLE I. Sechs Arten Nikotinsulfatlösung.

	Nikotin (%)	H <sub>2</sub> SO <sub>4</sub> (%)	Verdünnungsgrad
1	0.09	0.063—0.013	1: 444
2	0.03	..	1: 1333
3	0.0198	..	1: 2020
4	0.0149	..	1: 2693
5	0.011	..	1: 3600
6	0.0099	..	1: 4040

0.072 mg. 3) 0.051 mg. 4) 0.031 mg. 5) 0.018 mg. 6) 0.0098 mg. 7) 0.0025 mg.

Nach der Sammlung der Eier am Morgen werden sie unter der konstanten Temperatur (27°C) gehalten, wobei sie regelmässig sich entwickeln. Also in ihrer Eierperiode können wir fünf Stadien unterscheiden, wie folgt:

- das erste Stadium... innerhalb 24 Stunden nach der Auslegung.
- das zweite Stadium... von nach 24 Stunden bis zu 48 Stunden.
- das dritte Stadium... von nach 48 Stunden bis zu 72 Stunden.
- das vierte Stadium... von nach 72 Stunden bis zu 96 Stunden.
- das fünfte Stadium... von nach 96 Stunden bis zur Ausbtütung.

Beim Experimente streichen wir die Nikotinsulfatlösung von bekannter Konzentration mit dem Pinsel auf die ganze Oberfläche der Eier in allen obenerwähnten fünf Entwicklungszuständen aus, welche im unter 27°C. gehaltenen Thermostat gelegt wurden. Nach der Trocknung des gelegten Mittels wurden die Eier im kleinen Glasrohr in den Thermostat gelegt und jeden Morgen ihr Entwicklungsverlauf wurde unter den Mikroskope beobachtet.

Auch beim Experimente mit Nikotingase hängen wir schmal geschnittene Papierstücke mit ihren Eiern in die Glasflasche von etwa zwei Liter hinein, welche nach dem Legen des reinen Nikotins fest verschlossen wird. Um die Verflüchtigung des Nikotins zu beschleunigen, wärmen wir den Boden dieser Flasche etwas und dann legen sie vierundzwanzig Stunden lang im obenerwähnten Thermostat hinein. Nach der Beseitigung dieses Gases wird dasselbe Verfahren wie beim vorigen Experimente wiederholt.

## VERSUCHSRESULTATE

### (1) Vorbereitungsexperiment

Da durch die Wirkung des Nikotins die im Insektenkörper herrschende physiologische Vorgang gestört werden, so bilden die Experimentsresultate über seinem Entwicklungsverlauf unter der normalen Bedingung die

Grundlage dieser Untersuchung. Auch da die Klarstellung der Einwirkung der Schwefelsäure im Nikotinsulfate nötig ist, wurden die nachfolgenden Experimente als Vorbereitung für die weiteren Experimente gemacht.

Unter konstanter Temperatur von 27°C. brüten sich die Eier von *Chiolo simplex* gewöhnlich am 5.5-6sten Tage aus (Textfig. II). Im sofort nach dem Anlegen untersuchten Ei können wir nichts beobachten ausser dem Eiweiss, doch im Ei in seinem zweiten Stadium befindet sich ein kleiner Embryo etwas unter dem Mittelpunkt (an der Gegenseite der Mikropyle), dessen Kopf sichtbar als der Unterleib ist (vgl. Tafel XV. A). Der Embryo des Eies im dritten Stadium ist weiter entwickelt: die Segmenten des Unterleibes werden sichtbar, sein Kopf ist gross und nach innen gekrümmt und das Luftzimmer im Ei vergrössert sich etwa zu 1/4 des ganzen Eies (vgl. Tafel XV. B). Im Ei im vierten Stadium ist der Embryo mit Mundorgan und Augen versehen, zeigt linienförmige Flecke an der dorsalen Seite des Körpers und zeigt viele Borsten. Der

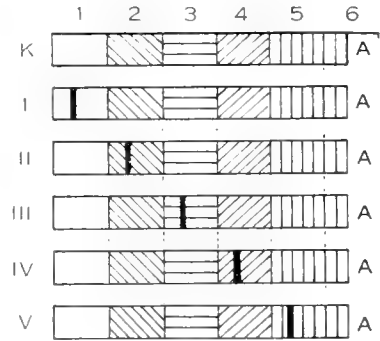


Textfig. I. Eilary im 5. Eie.



nach innen gekrümmte Hinterleib kommt mit dem Kopfe in Berührung, sodass der ganze Körper ringförmig ist (vgl. Tafel XV. C). Der Embryo im fünften Stadium gewinnt eine beinahe gleiche Gestalt wie die Larve nach der Ausbrütung: die Kopfkapsel und der Nackenschild zeigen gelbbraune Schattierung, die Anordnung der Stigmen und Borsten an jedem Segment war ganz regelmässig, und sowohl abdominale Kranzfüsse als auch Fühler sind schon vorhanden (vgl. Tafel XV. D und Textfigur I).

Wenn die Schwefelsäurelösung (0.063%) auf die ganze Oberfläche von Eier in irgend einem Stadium ausgestrichen wurde, so doch wuchs der Embryo ganz normal und war bei der Betrachtung am 6sten Morgen schon ausgebrütet (Textfig. II). Also in Bezug auf die Wirkung der Schwefelsäure können wir keine direkte Wirkung beobachten.



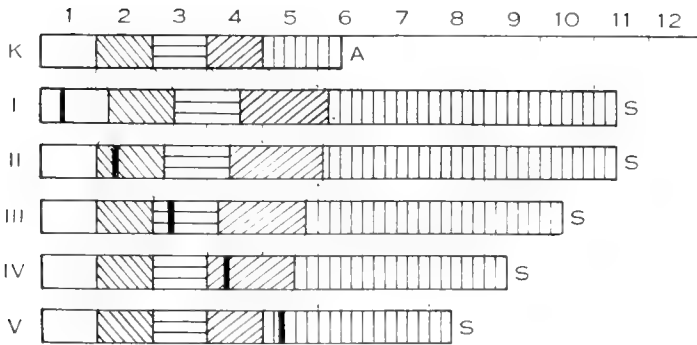
Textfig. II. Normale Entwicklung und dieselbe bei der Anwendung der Schwefelsäure. Die Ziffern 1, 2, 3—6 bedeuten die respektiven Entwicklungsstadien der Eier. I, II, III, IV V bedeuten die Eier, für welche die Anwendungszeit des Mittels verschieden ist. A. ausbrüten.

## (2) Experiment mit ausgestrichenen Nikotinsulfaten.

### Versuch I. Nikotin 0.09% (1:444)

Am 6. Morgen nach dem Eierlegen brüteten sich die Kontrolleier (K) aus, während dieselbe (I-V), wobei das Mittel gegeben wurde und welche noch in den Eierschale lebendig war, bald zugrunde gingen: die ersten<sup>1)</sup> und zweiten Eier (I, II) starben am 11. Tage, die dritten (III) am 10., die vierten (IV) am 9. und die fünften (V) am 8. (Textfig. III). Wie die Textfigur zeigt, ist das Wachstum ihres Embryo durch die Wirkung des Nikotins verspätet als das der Kontrolleier und je älter die Eier sind, desto

1) die ersten, zweiten usw. Eier bedeuten dieselbe, welche in den ersten, zweiten usw. Entwicklungsstadien vergiftet werden.



Textfig. III. Einwicklung bei 0.09% Nikotin. S. sterben A. ausbrüten.

schneller tritt ihr Tod ein, aber gewöhnlich zeigen alle tote Eier das letzte Form der Entwicklungsstadien, ohne dass sie nach der Mittelanwendung sofort sterben. Diese Tatsache betrachtete FEYTAUD auch in seinem Experimente mit *Polychrosis botrana* SCHIFF. und *Conchylis ambignelle* HBX.

Eigentlich ist die Giftwirkung der Nikotinlösung von der Menge des darin enthaltenen frischen Nikotins und von seiner Flüchtigkeit abhängig; die letztere steht selbstverständlich in enger Beziehung zur Temperatur und Feuchtigkeit der Luft, vor allem zur Wasserstoffionkonzentration der Lösung. Bei alkalischer Lösung flüchtet das Nikotin besser als bei sauer, also wirkt es am besten, wenn die Nikotinlösung genügend alkalisch ist. Nach der Untersuchung von DEONG ist die Giftigkeitskurve des Nikotins mit der Flüchtigkeitskurve desselben gleichlaufend. Von diesem Standpunkte aus experimentierte ich mit einem besonder gemischten Mittel, dessen pH-Wert nach der Säuremenge veränderlich ist (vgl. Tabelle II.). Aber

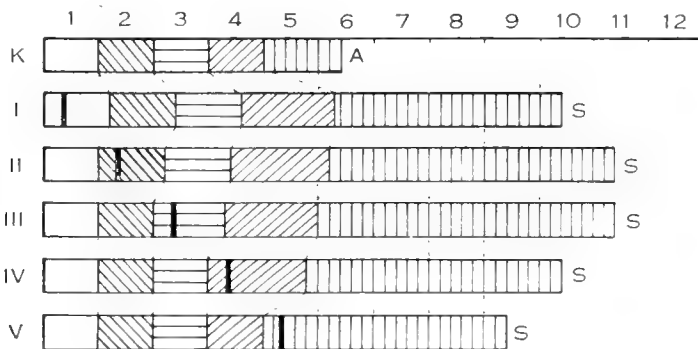
TABELLE II. Verhältnis zwischen der Säuremenge und pH-Werte.

	Nikotin (%)	Schwefelsäure (%)	pH-Wert
1.	0,09	0,063	2,86
2.	..	0,05	3,3
3.	..	0,038	4,25
4.	..	0,032	6,82
5.	..	0,025	7,85
6.	..	0,013	8,53
7.	..	..	8,74
8.	..	0,063	1,97

keinen deutlichen Unterschied ihrer Wirkung können wir nicht beobachten, denn die Menge des auf das Ei einwirkenden Mittels war vielleicht weniger als das Minimum.

Versuch II. Nikotin 0.03% (1:1333)

Die Kontrolleier brüteten sich am 6. Tage aus, aber die ersten Eier (I) starben am 10., die zweiten (II) und die dritten (III) am 11., die vierten (IV) am 10. und die fünften (V) am 9. (Textfig. IV). Auch bei diesem

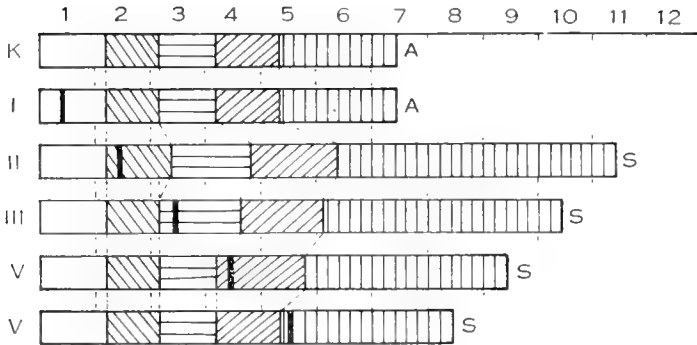


Textfig. IV. Entwicklung bei 0.03% Nikotin.

Experimente war das Wachstum ihrer Embryo länger als das der Kontrolleier und alle tote Eier hatten das letzte Form in dem Entwicklungsstadium behalten. Die älteren Eier wurden durch das Mittel schneller getötet als die jungen.

Versuch III. Nikotin 0.0198% (1:2020)

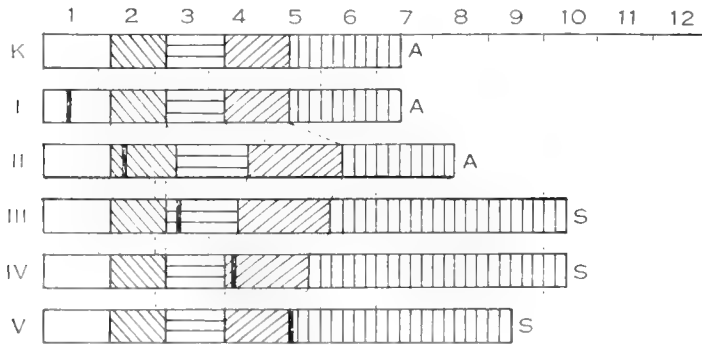
Die ersten Eier (I) brüteten sich aus am 7. Tage wie die Kontrolleier (K), während die anderen (II, III, IV, V) am 11., 10., 9. und 8. Tage starben. Das Wachstum der ersten Eier, welche eine einzige in diesem Versuche ausbrütende Art sind, ist fast gleich dem der Kontrolleier, woraus wir auf den Gedanke angekommen sind, dass das Mittel dieses Versuchs nur die älteren Eier zum Tode führt und nicht auf die noch nicht weit entwickelten wirkt. In Bezug auf die Zustände der toten Eier und das Verhältnis zwischen der Mittelanwendungs- und Todeszeit haben wir dasselbe Ergebnis wie beim Versuch I, II gehabt (Textfig. V).



Textfig. V. Entwicklung bei 0.0198% Nikotin.

## Versuch IV. Nikotin 0.0149% (1:2693)

Die ersten Eier (I) brüteten sich aus am 7. Tage wie die Kontrolleier und die zweiten (II) ein Tag nachher, während die dritten (III) und die vierten (IV) am 10. und die fünften (V) am 9. starben. Auch in diesem Versuche wurde das Wachstum des Embryos von den jungen Eiern vom Mittel nur verspätet, ohne dass sie getötet wurden. Aber durch dasselbe Mittel werden die anderen Eier (III, IV, V) getötet (Textfig. VI).

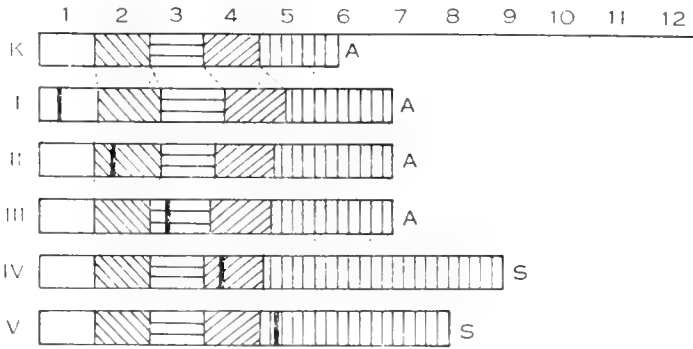


Textfig. VI. Entwicklung bei 0.0149% Nikotin.

## Versuch V. Nikotin 0.011% (1:3600)

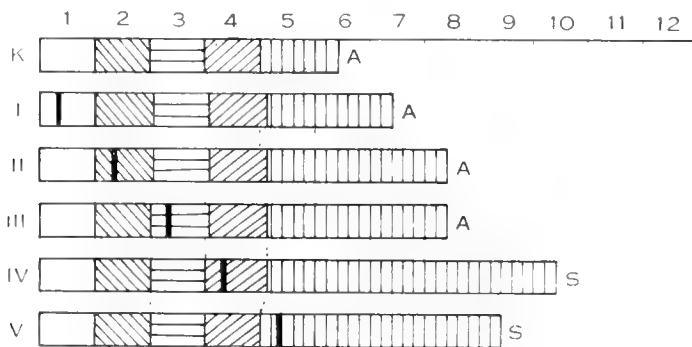
Mit einer kleinen Verspätung des Wachstums brüteten sich die ersten, zweiten und dritten Eier (I, II, III) am 7. Tage aus, aber die vierten (IV) starben am 9., und die fünften (V) am 8. Die Abtötungs-

wirkung dieses Mittels ist nur auf die älteren Eier beschränkt (Textfig. VII).



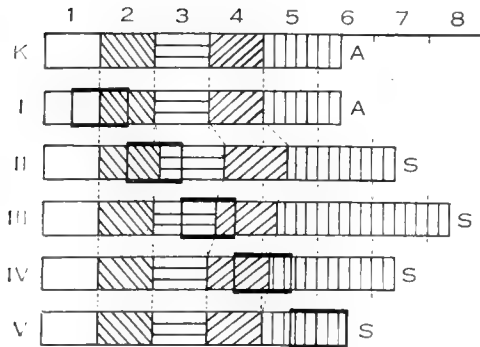
#### Versuch VI. Nikotin 0.0099% (1:4040)

Die ersten Eier (I) brüteten sich aus am 7. Tage und die zweiten sowie dritten (II, III) am 8., aber die vierten (IV) und die fünften (V) starben am 10., 9. ab. In diesem Versuche ist die Verspätung ihres Wachstums durch das Mittel nicht so deutlich ausgeprägt wie beim vorigen (Textfig. VIII).



## (3) Experiment mit Nikotingase.

## Versuche VII. Nikotin 0.2836 mg./L.

Textfig. IX. Entwicklung bei  
0.2836 mg./L. Nikotin.

Die Kontrolleier (K) und die ersten (I) brüteten sich am 6. Tage aus, aber die zweiten (II) und die vierten (IV) starben am 7. ab, während die dritten (III) am 8. und die fünften (V) am 6 (Textfig. IX). Die Tageszahl bis zum Tode ist viel kürzer als beim Experimente mit ausgestrichenen Mittel, aber das Wachstum ihres Embryos wurde verspätet wie beim vorigen, welcher im letzten Form der Entwicklungsstadien getötet wurde. Je älter die Eier sind, desto schneller wird ihr Embryo durch die Mittelanwendung getötet, z. B. die fünften Eier (V) schon am nächsten Tage der Vergiftung. Die durch schwarze grobe Linie begrenzten Rechtecke im Textfigur IX zeigt die Zeitdauer, währenddessen die Eier im das Nikotingas enthaltenden Gefässe eingeschlossen war.

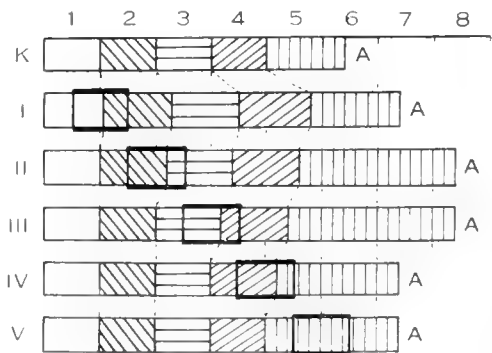
## Versuch VIII.

Nikotin 0.072 mg. L.

Die ersten, vierten und fünften Eier (I, IV, V) brüteten sich aus am 7. Tage, sowie die zweiten und dritten (II, III)

am 8 (Textfig. X). In diesem Versuche können wir keine Abtötungswirkung des Nikotins beobachten, aber in Bezug auf in den anderen

Die Kontrolleier (K) und die ersten (I) brüteten sich am 6. Tage aus, aber die zweiten (II) und die vierten (IV) starben am 7. ab, während die dritten (III) am 8. und die fünften (V) am 6 (Textfig. IX). Die Tageszahl bis zum Tode ist viel kürzer als beim Experimente mit ausgestrichenen Mittel, aber das Wachstum ihres Embryos wurde verspätet wie beim vorigen, welcher im letzten Form der Entwicklungsstadien getötet wurde. Je älter die Eier sind, desto schneller wird ihr Embryo durch die Mittelanwendung getötet, z. B. die fünften Eier (V) schon am nächsten Tage der Vergiftung. Die durch schwarze grobe Linie begrenzten Rechtecke im Textfigur IX zeigt die Zeitdauer, währenddessen die Eier im das Nikotingas enthaltenden Gefässe eingeschlossen war.

Textfig. X. Entwicklung bei  
0.072 mg./L. Nikotin.

Hinsichten haben wir dasselbe Ergebnis wie beim vorigen.

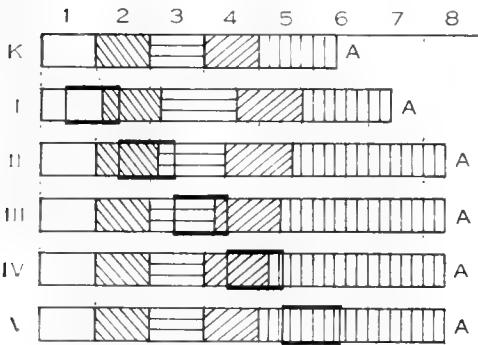
Versuch IX. Nikotin 0.051 mg./L.

Alle Eier (II, III, IV, V) brüteten sich aus am 8. Tage, abgesehen von den ersten und den Kontrolleier, von denen die ersteren (I) am 7. Tage und die letzteren am 6. sich ausbrüteten. (Textfig. XI).

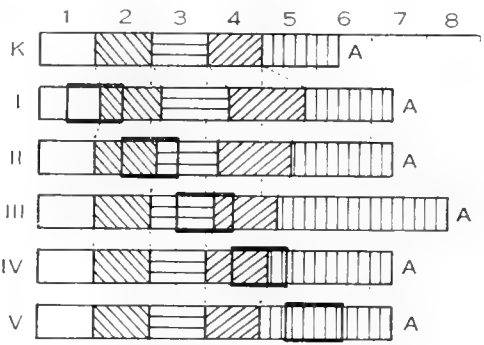
Versuch X. Nikotin 0.031 mg./L.

Versuch XI. Nikotin 0.018 mg./L.

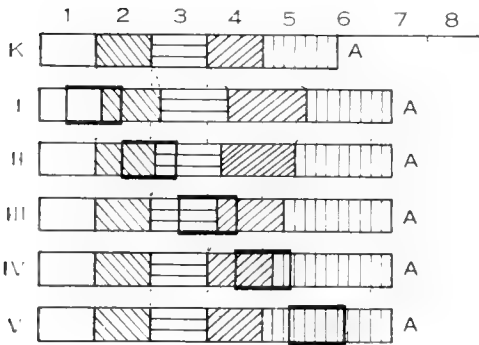
Nur die dritten Eier (III) brüteten sich aus am 8. Tage und die anderen (I, II, IV, V) am 7 (Textfig. XII).



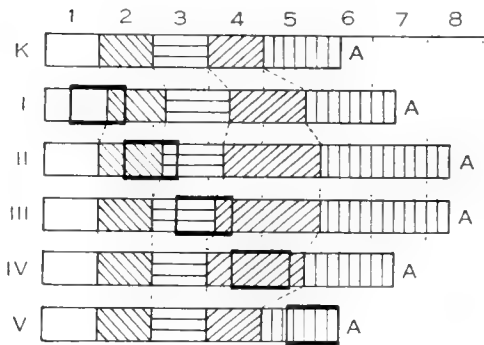
Textfig. XI. Entwicklung bei 0.051 mg./L. Nikotin.



Textfig. XII. Entwicklung bei 0.031 mg./L. Nikotin und bei 0.018 mg./L.



Textfig. XIII. Entwicklung bei 0.0098 mg./L. Nikotin.



Textfig. XIV. Entwicklung bei 0.0025 mg./L. Nikotin.

Versuch XII. Nikotin 0.0098 mg./L.

Alle Eier brüteten sich aus am 7. Tage (Textfig. XIII).

Versuch XIII. Nikotin 0.0025 mg./L.

Die ersten und vierten Eier (I, IV) brüteten sich aus am 7. Tage aus, die zweiten und dritten (II, III) am 8. und die fünften (V) am 6. Tage wie die Kontrolleier (Textfig. XIV).

Im allgemeinen fand die Ausbrütung der Eier bei diesem Experimente mit Nikotinsäure weit schneller statt als beim vorigen. Die Verspätung des Wachstums, das Form des toten Embryos und das Verhältnis zwischen Mittelanwendungs- und Todeszeit sind ganz gleich wie beim vorigen.

#### DISKUSSION

Seitdem DESELLEN die Tatsache entdeckt hatte, dass das Nikotin als Bekämpfungsmittel für die schädlichen Insekten, besonders für die Eierabtötung, sehr wertvoll ist, war die Anwendung des Nikotins vielfach ausgeübt worden. Gegen die Eier von *Malacosoma pini* STRETH und *Laspeyresia pomonella* L. hat LOVETT die Nikotinsulfat-Seifenlösung gebraucht und ihre starke Abtötungskraft nachgewiesen. Aber beim Experimente im Laboratorium sowie in Freiland konnten McINDOO, SIMANROX, PLANK und FISKE keinen so guten Erfolg wie beim vorigen gewinnen. Wenn auch viele andere Experimente ausgeführt worden sind, hat man noch keinen bestimmten Erfolg in Bezug auf die Wirkung des Nikotins als das Eierabtötungsmittel bekommen, sodass einer es wirksam denkt, die anderen aber nicht. Natürlich hängt die Wirkungsweise des Insektiziden von ihrer Verfertigungsmethode (Arten und beigefügtes Mittel), den Arten der Schädlingen und auch der Zeit der Anwendung des Mittels ab. Wir können somit die bisher ausgeführten Experimente miteinander ohne weiteres nicht vergleichen. Meine Untersuchungen im Laboratorium haben aber die gute Wirkung des Nikotins gezeigt.

Die Experimente der bisherigen Autoren sind hauptsächlich auf die



Abrechnung des Abtötungsprozentsatzes des Nikotins beschränkt und ungenügend in Bezug auf die Beobachtung der schädlichen Insekten selbst. Zuerst über die Anwendungszeit können wir in Bezug auf die bereits gewonnenen Resultate etwa zwei Gruppen unterscheiden: die erste bezieht sich auf die Untersuchung von McINDOO und den anderen, in welcher sie das gleichartige Mittel an den Eiern von *Laspeyresia pomonella* L., *Bombyx mori* L., *Hemerocampa leucostigma* S. & A. und *Leptinotarsa decemlineata* L. in ihren verschiedenen Eintwicklungszuständen anwandten und dann beobachteten, dass junge Eier mehr als ältere vernichtet werden, weil der Bau der Eierschale in verschiedenen Stadien verschieden ist. An der anderen Seite gibt es die PETERSON's Untersuchung über die Eier von *Aphis aucanae* FEB., *A. pomi* DEG. und *A. sorbi* KALT., deren Erfolg dem vorigen entgegengesetzt ist: in den älteren Eiern konnte er den höchsten Abtötungsprozentsatz bekommen, was YAGO auch beobachtete. Meiner Untersuchung nach können die über 0.03% Nikotinlösung (1:1333) in jeden Entwicklungsstadium des Embryos in den Eiern vollständig den Zweck der Eierabtötung erfüllen (Tabelle III), wenn die wenigprozentigen (unter 0.03%) nur die älteren Eier vernichten und bei den jüngeren ihr Wachstum hemmen können. (vgl. Versuch III, IV, V,

TABELLE III. Vergleichung der sechsartigen Nikotinsulfatlösungen für ihre Eierabtötungswirkung.

Eier	Die Ersten	Zweiten	Dritten	Vierten	Fünften
Mittels					
0.09%	Sterben	S.	S.	S.	S.
0.03	S.	S.	S.	S.	S.
0.0198	Ausbrüten	S.	S.	S.	S.
0.0149	A.	A.	S.	S.	S.
0.011	A.	A.	A.	S.	S.
0.009	A.	A.	A.	S.	S.

VI). Mit anderen Worten durch die Wirkung des Mittels verspätet sich die Entwicklung des Embryos von *Chilo simplex* ohne sofort getötet zu werden, wenn sie noch ganz jung sind. Aber wenn sie sich schon im

letzten Zustände ihres Wachstums befinden, können sie nicht überleben, d. h. bei diesem Zustande sind sie am empfindlichsten gegen die Wirkung des Nikotins. Also bei den älteren Eiern können wir ihre hochprozentige Abtötung bekommen, wie es bei den PETERSON'S Untersuchung der Fall war. Also trotzdem das Mittel auch Abtötungskraft hat, gibt es der Fall, wobei es keine Wirkung zeigen kann, je nach den Entwicklungszuständen des Embryos (vgl. Versuch III, IV, V, VI). Ueber die Verspätung der Entwicklung äusserte sich McINDOO schon in seiner Schrift. Bei der Vergiftung mit dem dünnen Mittel ist die Verspätung des Wachstums selbstverständlich weniger und die Zeitraum der Eier ist kürzer als bei der mit stärkeren, wie viele Beispiele in meinen Experimenten zeigen.

Zweitens in Bezug auf der Eierabtötungswirkung des Nikotins kann ich noch keine befriedigende Erklärung geben, da die dafür dem eingerichteten Untersuchung noch im Gange sind. Die Ergebnisse unserer bisherigen Untersuchungen fühlen doch uns zum folgenden Gedanke. Im allgemeinen atmen die Insekteneier durch ihre Eierschale sehr spärlich. Wenn wir das Mittel auf die Eierschale pinseln, so bildet es darüber eine dünne Schicht, welche die Berührung der äusseren Luft mit den Eier so hemmt, dass dadurch der Tod der Insekten durch die Erstickung eintreten kann. Aber beim obenbeschriebenen Untersuchungen haben wir gesehen, dass bei der Anwendung des Mittels die Eier ihre Entwicklung fortsetzten ohne sofort abzusterben und dass alle tote Eier sich im letzten Zustande der Entwicklung befanden. Die Ursache des Todes in diesem Falle ist also keine Erstickung, sondern die chemische Giftwirkung des Mittels. Theoretisch ist das Nikotinsulfat unflüchtig, doch nach der Untersuchung von DEONG und WORTHLEY ist seine Flüchtigkeit mehr oder weniger erkennbar. Wie wir schon beim Versuche I. gesprochen haben, bedeutet die sogenannte Flüchtigkeit des Nikotinsulfates nur die des Nikotin; auch nach den Untersuchungen von McINDOO und T. YUBATA kann das akkulierte Nikotingas nicht leicht beseitigt werden. Sowohl beim Experimente mit gestrichener Nikotinsulfatlösung als auch beim mit Nikotigase bekommen wir gleiches Ergebnis, während die Schwefelsäure

keine direkte Wirkung hat. Durch diese Tatsache können wir erkennen, dass das Mittel selbst nicht in die Eier eindringt, sondern das Nikotingas, welches an der Eierschale akkumuliert war, von dem Embryo eingeatmet wird, was zu seinem Tode führt.

Die physiologisch-toxische Wirkung des Nikotins besteht hauptsächlich in der Nervengiftung, vor allem des vegetativen Nervensystems—Parasympathicus und Sympathicus: anfangs werden sie erregt und dann gelähmt, so dass die Atmung und die Herztätigkeit sehr stark erniedrigt werden, was zum Tode führen kann. Kurz, wir erkennen im Nikotin zwar eine ganz resorptive funktionale Wirkung, aber keine dem anderen Giftgase ähnliche ätzende, so dass das Nikotin in enger Beziehung zur Entwicklung des Nervensystems steht. Ueber diese hat GREENWOOD schon in seinen Experimente beobachtet, dass die giftige Wirkung des Nikotins auf jeden Organismus hauptsächlich durch den Grad der Entwicklung seines Nervensystems bestimmt wird. Wie unsere Untersuchungen gezeigt haben, ist *Chilo simplex* in seinem jungen Eierstadium gegen Nikotin keineswegs empfindlich, denn zu dieser Zeit sind seine Nerven noch nicht vollständig entwickelt. Also trotz der Anwendung des Mittels wachsen seine Embryonen weiter; sobald als die vollentwickelten Nerven und Tracheen zu funktionieren beginnen, dann erst geschieht die Erregung und Lähmung der Eilarve durch die Giftwirkung, und ihre Leben kann zum Stillstand kommen.

### SCHLUSSBETRACHTUNG

Die Eier von *Shilo simplex* BUTLER brüten sich aus am 5.5–6sten Tage bei konstanter Temperatur (27°C), und bei ihren Eiern können wir keine direkte Wirkung des in der Nikotinsulfatlösung enthaltenen Schwefelsäure erkennen. Freilich bei der Anwendung des dünnen Mittels überleben sie mit kleiner Verspätung ihres Wachstums aber bei der des starken wird das Wachstum der Eier beträchtlich verspätet als das der Kontrolleier. Gewöhnlich bei der Mittelanwendung sterben sie nicht sofort ab, sondern ist ihr Wachstum verspätet, um schliesslich sie in ihrem letzten Ent-

wicklungsstadium zu Grunde gehen. Da ihr Tod in älteren Eiern schneller als in jungen eintritt, so können wir bei der ersten eine höchprozentige Abtötung bekommen, aber dabei ist es nötig, die über 0.03% Nikotinsulfatlösung anzuwenden, um die Eier in allen Entwicklungsstadien spurlos vernichten zu können. Die Ursache ihres Todes durch das Nikotinsulfat ist keine Erstickung, sondern die chemischen Giftwirkung des Nikotingases, welches an der Eierschale akkumuliert war und bei der Einatmung durch die Tracheen in den Insektenkörper eindringt, die Erregung und Lähmung des Nervensystems herbeiführt und das Leben der Schädlingen vernichtet. Also seine Giftwirkung steht in enger Beziehung zum Nervensystem, sodass ein für die Abtötung der älteren Eier genügend kräftige Nikotingas den Embryo in den jungen Eiern gar nicht töten kann. Sobald die Nervensysteme und Tracheen ihre Entwicklung vollendet und ihre Funktion beginnen, werden die Eier durch die Giftwirkung des Nikotingases getötet, sodass die älteren Eier für das Nikotin sehr empfindlich sind. Dies erklärt wohl die Tatsache, dass alle tote Eier das Form im letzten Entwicklungsstadium annehmen.

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## TAFELERKLÄRUNG

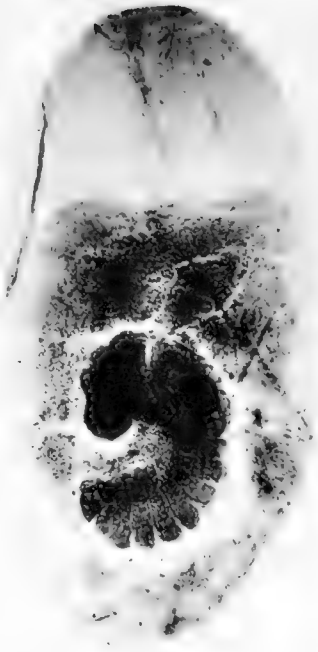
## TAFEL XV.

- A. Embryo des Eies im zweiten Stadium.
- B. Embryo des Eies im dritten Stadium.
- C. Embryo des Eies im vierten Stadium.
- D. Embryo des Eies im fünften Stadium.

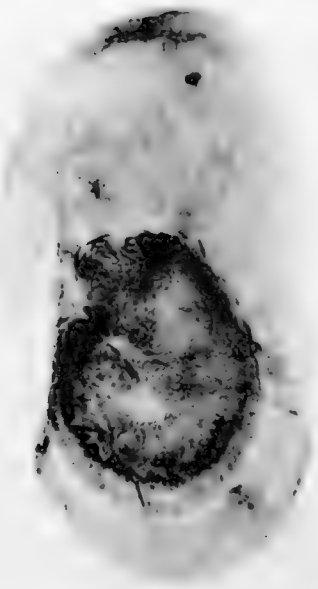
A



B



C



D







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