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AN INVESTIGATION OF THE RAT PEST PROBLEM IN QUEENSLAND CANEFIELDS: 3. LABORATORY EXPERIMENTS ON FOOD INTAKE AND TOXICITY.

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SUMMARY.

1. Methods for the initial cage test evaluation of bait bases, poisons, poisoned foods and baits for Queensland canefield rats are described. Mean standard intake and median lethal dose, either singly or conjointly, are used as criteria.

2. Whole grain, such as that of wheat and oats, is the most efficient food bait base.

3. Thallous sulphate and yellow phosphorus are considered to be suitable poisons. Arsenic, barium carbonate, barium chloride, red squill, and strychnine are unsatisfactory for various reasons.

4. The addition of flavourings and/or attractants does not increase the intake of a particular poisoned food by individual rats: this can be varied only by altering the poison strength.

INTRODUCTION.

The primary object of the experiments concerned with food intake and with toxicity of rat poisons was to collect data on recognized rat poisons for use in field studies on poisoning. In initiating the experiments it was considered that cage test results would assist in the interpretation of field data and in setting out field experiments. It was appreciated, however, that field results cannot be expected to parallel those obtained in cage tests, since the factors which can be studied in part away from the field—viz., palatability, as expressed by intake, and toxicity—are only two of the many concerned in the successful poisoning of rats in the field.

No serious attempt was made during the course of the experiments to discover new rat poisons.

METHODS.

Except where it is stated to be otherwise, *Rattus conatus* Thomas was the test animal employed. In comparative studies only healthy, apparently normal, active adults were used. It is common experience that immature rats exhibit irregular and abnormal intakes expressed as a function of individual body weight. Old animals were excluded from the tests as their death from natural causes could be regarded as imminent. Occasionally these rats died in test cages without eating or after feeds of various amounts of unpoisoned food; many deaths were recorded after intakes of small, sub-lethal doses of poison, while other rats required the normal amounts of poison to kill them. A few rats of suitable age and size, when first placed in test cages, ate either no food at all or obviously sub-normal amounts. Such specimens were not as active as usual at the time, and most of them, whether transferred from dormitory living cages or from the field, behaved normally a few days later.

With cage experiments an effort is usually made to standardize the condition of test animals, and this often consists of holding wild captures in living cages for some period prior to testing and/or starving all specimens before offering weighed food or baits. None of these procedures was necessary in the case of the species used in this investigation: the use of suitable rats either direct from the field or from dormitory living cages was found to be

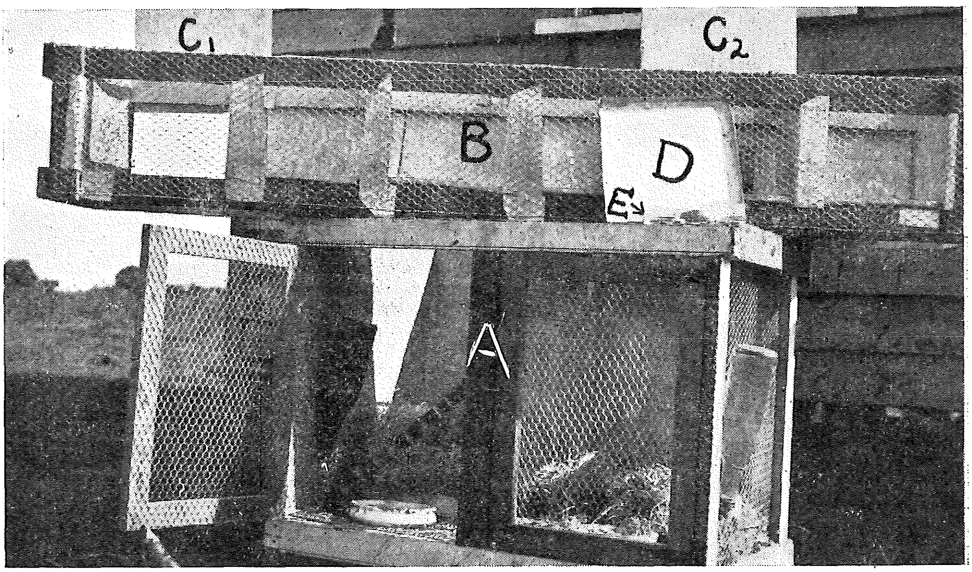

Plate 1.

RAT CAGES USED IN THE EXPERIMENTS:

A.—Breeding and living cages.
B.—Battery of six test cages.
C_1. and C_2.—Sliding backs of test cages.
D.—Tray floor of a test cage.
E.—Glass containers for poison work.

statistically sound, provided some simple precautions were taken. Those from fields for use on any particular day must be removed from traps before sunrise, and must be provided with bedding during travelling and while in the dormitory awaiting transfer to test cages.

Practically all of the cage work was carried out between July, 1937, and November, 1940, and about 3,500 rats were handled, mostly during the winter and spring months when field capture of suitable rats was easier than at other times. There is, however, no significant difference in food intake attributable to season of testing.

Test cages (Plate 1, B), each 10 inches x 11 inches x 10 inches, with removable tray floor (D) and sliding back (C_1, C_2), were arranged in batteries of six (B) and were always set up during the afternoon. Usually only one test rat was placed in each cage. All test animals and most test materials, the latter contained in glass containers (E) where necessary, were weighed before being placed in cages. For repeat tests the weight of a rat at the original test was usually taken; however, if a rat had increased in weight between tests the larger weight was used. On clearing cages during the morning—the test period was over one night—all animals, whether dead, sick or apparently normal, and all uneaten test material, were weighed. Live animals were transferred to dormitory living cages (Figure 1, A) for observation. To obviate fighting, which would interfere with the test results, care was taken to return dormitory rats to their original cages and field rats to unoccupied cages.

Takano and Konoda (1937), in reporting feeding studies with *Bandicota nemorivaga* Hodgson, a rat pest of cane in Formosa, listed food intake variations due to the presence of water, and many other investigators provide water in the test cages. With Queensland canefield species, under normal conditions, the presence of water has no influence on cage food intake. For overnight holding in the small test cages used it was unnecessary to provide bedding.

The common base for the poisons tested was a prepared food, made to the formula of the standard dormitory food*, but omitting the mixture of salts and Vita B, and passed through a ½ mm. sieve. The poisons, after grinding when necessary, were thoroughly mixed with this fine material in the desired proportions by weight. Various grains and other potential bait bases were also used. The weight of any food material offered to a rat was always in excess of its stomach capacity, *i.e.*, intake would not be limited by the supply available. Feeding levels, or weighed amounts of food below normal intake and containing stipulated poison doses, were used sparingly and only when required for checking median lethal doses. Tests with unpoisoned food, primarily for periodical checking purposes, were also used in calculating food intakes. Attempts to use poisons in liquid form or in water solution were failures. This

* The formula of the standard dormitory food will be given in a later part of this series.

method is apparently inaccurate, unreliable, and also of little practical application in canefields.

The median lethal dose (M.L.D.), *i.e.,* the dose of poison which could be expected to kill 50 per cent. of the test animals, has been taken as the criterion for comparing toxicities. Food and bait base standard intakes are expressed as grams of food or bait base per gram body weight of rat (g./g.) and poison standard intakes as milligrams of poison per kilogram body weight of rat (mg./kg.). Weights of poisons when in salt form have been taken in all instances as those of the salts used and not as the calculated weight of any elements which may be the toxic principles.

Results of food preference tests, *i.e.,* tests in which two or more foods are offered simultaneously to a rat, have been examined by Analysis of Variance when three or more foods were concerned, and by the "Student" test for the difference between pairs when two foods were offered. Individual rats have been considered as blocks and each food as a treatment; the 5 per cent. level is taken for significance. The probable economic and practical value of preference tests for canefield work is doubtful; therefore, the recording of the results of such tests is merely formal. More emphasis has been placed on the mean standard intakes of foods presented singly to rats. Any series of such experiments examined statistically has consisted of not less than 25 tests, and a standard error is given.

It is necessary to distinguish between the terms *take, consumption, acceptance,* and *intake.* In the field, or in other control application work, poison baits when placed out may be counted. Later a check count is made and the difference between the original and check counts is called *take*; the *take* depends on the attractiveness and palatability of the bait, and the number and weights of rats or other animals interfering with them. Sometimes in the field when packeted baits are used those opened and eaten or partially eaten are examined. The estimate of the number of baits eaten is called *consumption. Take,* therefore, includes those baits accounted for by the consumption and missing baits. *Acceptance* is used in an indefinite manner in referring to palatability. On occasions, in reporting cage test results, all four terms are used in the literature indiscriminately. The author uses the term *take* only when material offered to animals has not been weighed or measured. *Intake* is the known weight of food or other substance ingested by a rat or rats.

Two classes of baits are recognised—viz., food baits and snap baits. In preparing food baits, attractiveness, intake, and toxicity are factors to consider so far as killing power is concerned. The poisoned food of food baits may be presented to rats by methods other than in baits. Snap baits should have some degree of attractiveness and very high toxicity, for under even the most favourable circumstances intake of a snap bait by an individual rat will be very small or negligible; its killing power depends on high toxicity and not on appreciable intake.

FOOD AND OTHER BAIT BASE INTAKES.

Choice of Base.

The choice of a food or other bait base for use in a rodent control problem is governed by palatability, availability, convenience of storage, ease of handling, deterioration qualities, suitability for use with particular poisons, and the scope of the problem, which includes areas and/or bulks infested and periods of infestation. These factors involve a consideration of the habits of the rodent species concerned, of the economic status of the problem, of the working environment, of the manner of presenting poisoned foods to the pests, and of the methods of preparing the poisoned foods, *i.e.*, whether in bulk by manufacturers or in small lots, as required, by individual farmers or other people concerned. Food and other bait bases listed by numerous authors therefore cover a wide field, although most food baits for use on a large scale against vegetarian species have either grain or grain derivatives as bases.

In Table 1 are given the more important foods used in the author's experiments and the respective mean standard intakes by *R. conatus*. The mean standard intake of wheat by *Melomys littoralis* is 0·133± ·003 g./g.

Table 1.

SHOWING MEAN STANDARD INTAKES OF FAVOURED (A) AND SECONDARY (B) FOODS.

	Food.		Mean Standard Intake g./g.
A	Prepared food		·071 ± ·004
A	Rolled oats*		·074 ± ·003
A	Hulled oats*		·066 ± ·006
A	Unhulled oats*		·064 ± ·007
A	Hulled barley		·071 ± ·004
A	Wheat		·064 ± ·002
A	Whole maize		·055 ± ·003
A	Cracked maize		·057 ± ·004
B	Bread	1st night	·048 ± ·012†
B	Bread	2nd night	·040 ± ·008†
B	Bread	3rd night	·025 ± ·001†
B	Bran		·032 ± ·004
B	Peanut meal		·010 ± ·006
	Sugar cane		·465 ± ·063‡

* From a reading of Doty (1938) the following synonyms are apparent :—

Australia.	*Hawaii.*
Cracked or hulled oats	Rolled oats
Rolled oats	Crushed oats.

† Correction, based on weighed checks, has been made for drying out.

‡ Correction, based on weighed checks, has been made for drying out of cane and frass. Weight of frass has been allowed for.

Intakes of meat, fish, cheese, bacon and other animal products by murine species indigenous to Queensland canefields are so poor that a detailed consideration of these materials is unnecessary.

Dry foods in Table 1 are divided into favoured or desired foods (A) and secondary foods (B). Intakes of dry intimate mixtures of favoured and secondary foods depend on the mean standard intakes of the individual foods and the relative percentages of the two food types. Poor intakes are recorded when the percentage of secondary foods is high. Separate discussions of the two types of food are given hereunder.

Favoured Foods.

Contamination.—It is common experience that rats will not eat food affected by moulds, weevils, or ants.

Rat Preference for Different Grains.—Two-food and three-food preference tests with four grains showed the order of preference to be oats, maize, wheat, barley. An example of a two-food preference test is given in Table 2.

Table 2.

Showing Results of a Preference Test with Hulled Oats and Whole Wheat.

Rat No.	Foods.	Individual Food Intakes. g.	Total Intake. g.	Standard Intakes of Individual Foods. g./g.	Standard Intake. g./g.	Weight of Rat (g.), and Sex.
1541	Hulled oats . .	7·63	7·77	·065	·066	117 ; F.
	Whole wheat . .	0·14		·001		
1542	Hulled oats . .	12·24	14·24	·051	·059	242 ; M.
	Whole wheat . .	2·00		·008		
1543	Hulled oats . .	9·51	9·51	·075	·075	127 ; F.
	Whole wheat . .	0·00		·000		
1544	Hulled oats . .	6·55	7·66	·056	·065	118 ; M.
	Whole wheat . .	1·11		·009		
1545	Hulled oats . .	7·19	9·64	·047	·063	153 ; M.
	Whole wheat . .	2·45		·016		
1546	Hulled oats . .	8·40	9·94	·060	·071	140 ; M.
	Whole wheat . .	1·54		·011		
1547	Hulled oats . .	5·39	5·39	·055	·055	98 ; M.
	Whole wheat . .	0·00		·000		
1548	Hulled oats . .	3·51	5·40	·039	·060	90 ; F.
	Whole wheat . .	1·89		·021		
1549	Hulled oats . .	5·36	6·63	·063	·078	85 ; F.
	Whole wheat . .	1·27		·015		

Mean Hulled Oats	Mean Whole Wheat	Mean difference, Hulled Oats—Whole Wheat	Result
0·057	0·009	0·048 ± ·006	Highly significant

Percentage preference

Hulled Oats—Whole Wheat
86% 14%

Mechanical Condition of Grain.—*Rattus conatus* prefers the cracked grain of a particular cereal and *Melomys* spp. the whole grain. Some results of two-food preference tests with *R. conatus* are as follows:—

Rolled oats v. oats: Significant preference for rolled oats.

Rolled oats v. maize: Significant preference for rolled oats.

Unhulled oats v. cracked maize: Significant preference for unhulled oats.

Unhulled oats v. wheatmeal: Significant preference for unhulled oats.

Hulled oats v. flour: Significant preference for hulled oats.

Cracked maize v. flour: Significant preference for cracked maize.

Cracked maize v. wheatmeal: Significant preference for cracked maize.

Cracked maize v. wheat: Significant preference for cracked maize.

Wheat v. cracked wheat or wheatmeal: Significant preference for cracked wheat or wheatmeal.

Wheat v. cracked barley: Significant preference for wheat.

Wheatmeal v. cracked barley: Significant preference for wheatmeal.

Judged on intake, it is concluded that the grain substance is of more importance than the mechanical condition of the grain.

Wetting of Grain and the Addition of Solutions.—The introduction of poison into grain for use in the field is usually effected by the addition of the poison in water solution or in a fluid mixture. The wetting of whole grain has a tendency to reduce intake, while the grain is wet, but on drying the intake is usually normal provided the grain has not become mouldy. This is not so with cracked grain or grain derivatives. As an example: Rolled oats, wheatmeal, and prepared food were wetted by water or by a solution, without the poisons, such as used by Barnum (1930) for the preparation of strychnine-wheat and thallous sulphate-wheat. These foods were then dried and test fed to rats. The intakes under optimum conditions were only approximately 50 per cent. of those of the unwetted foods. In fact, favoured foods such as cracked grain or grain derivatives when wetted and dried are reduced to the status of secondary foods. This has an important field application, for the wetting or dampening of grain or grain derivatives is unavoidable under most field conditions.

Starch paste (which is sometimes used for the introduction into whole grain food of insoluble poisons), molasses, and golden syrup have little effect on intake of grain food, provided they are used in comparatively small amounts.

Addition of Flavourings and Attractants to Favoured Foods.—The records of a typical series of three-food preference tests, with raw linseed oil added in turn to one of the foods immediately before testing, are given in Table 3. The results indicate that fresh raw linseed oil is an attractant. Single-food feeding tests demonstrate, however, that its use does not increase the mean standard intake of any food by an individual rat; this intake depends on the food substance itself. In other words, linseed oil, and similarly other known attractants, are purely attractants and not appetizers or flavourings. Materials used as attractants are usually poor foods and are added to grain bait only as thin smearings. Furthermore, if a series of tests as recorded in Table 3 is repeated three or more days after the attractant has been added to the food its presence is not indicated by intakes; the effect of all known attractants is transient. This point is also demonstrated when trapping. A well-used trap may be liberally coated with dry linseed oil, but for rebaiting a few drops of fresh oil must be added to the bait base carrier (McDougall, 1944).

Table 3.

SHOWING EFFECT OF RAW LINSEED OIL ON FOOD INTAKE.

Test.	Food Offered and Percentage Preference.		Summary of Results.
A (9 rats)	Barley	11·2	Intake of oats significantly exceeds those of barley and wheat.
	Oats	63·9	
	Wheat	24·9	
B (7 rats)	Barley	7·3	Intake of oats significantly exceeds those of barley and wheat plus linseed oil; wheat plus linseed oil exceeds barley.
	Oats	58·8	
	Wheat plus linseed oil	33·9	
C (8 rats)	Barley	0·7	Intake of oats plus linseed oil significantly exceeds (at 1% level) those of barley and wheat.
	Oats plus linseed oil	97·0	
	Wheat	2·3	
D (10 rats)	Barley plus linseed oil	13·1	Intake of oats significantly exceeds (at 1% level) those of barley plus linseed oil and wheat.
	Oats	80·5	
	Wheat	6·4	

The evaluation of any increases in collective intake due to the addition of attractants to foods is a field study.

Colouring of Foods.—Yellow, red, green, blue, and violet colouring agents have been used with various foods in controlled experiments. Colour has no significant effect on intake or on food selection by rats. In Queensland it is compulsory by law to colour any poison used in rat eradication; the author generally uses methylene blue for this purpose. Borden (1941) has listed Sudan red III. and Sudan red IV. as suitable for direct use with oils.

Addition of Poisons to Favoured Foods.—The addition to favoured foods of any of the poisons tested depresses intake. For rat species indigenous to Queensland canefields no method of masking the presence of poisons in food is known. Change of food or addition of flavourings does not alter depression of intake due to poisons; intake, in general, can be varied only by altering poison strength. There are a few exceptions, the reason for which is chiefly mechanical. For example, yellow phosphorus paste, and poisons with poor toxicity, such as barium carbonate, are more efficient when used in grain derivatives than when used with whole grain; also, with some poisons at weak poison strength, there is a tendency for depression of intake to be relatively larger with finely-ground grain derivatives, such as wheatmeal, prepared food, and flour, than with whole grain. This is of little importance, for in these instances when intake approaches the lethal dose the intake of poisoned food is not influenced by the mechanical condition of the food.

Rat Preference for Different Parts of the Grain.—When grain such as wheat is offered to a house mouse (*Mus musculus*) population larger than is necessary to deal with the weight of grain supplied, approximately 25 per cent. by weight of the grain is not eaten. The leavings are mostly grain shells. The indigenous murine species in canefields tend to eat the whole of each grain separately and completely. When the amount of grain approaches that necessary to feed any given population, leavings are negligible. Gard (1935) found that Queensland canefields species did not peel off the skin of strychnine-coated wheat to avoid the poison. Often the harder part of the large maize grain is discarded when first encountered, but eventually practically all the grain is eaten.

Intakes of Favoured Foods in the Presence of Sugar Cane.—The two-food preference test shown in Table 4 illustrates the indeterminate results obtained in a small test cage when sugar cane was one of the foods offered.

Table 4.

Showing Intakes of Favoured Foods in the Presence of Sugar Cane.

Rat No.	Foods Offered.	Intake. g.	Standard Intake. g./g.	Weight of Rat (g.), Species, and Sex.
562	Sugar cane	10·0	·303	33 ; *M. littoralis* ; M.
	Wheat	3·43	·104	
563	Sugar cane	5·5	·204	27 ; *M. littoralis* ; F.
	Wheat	0·0	..	
564	Sugar cane	5·5	·063	87 ; *R. conatus* ; F.
	Wheat	3·79	·044	
565	Sugar cane	30·5	·368	83 ; *R. conatus* ; F.
	Wheat	0·0	..	
566	Sugar cane	9·0	·098	92 ; *R. conatus* ; M.
	Wheat	6·0	·065	
567	Sugar cane	8·0	·103	77½ ; *R. conatus* ; F.
	Wheat	2·05	·027	

Secondary Foods.

When a selection of secondary foods is offered over a test period, the total food intake does not exceed that of the best of them when it is presented alone. The intake of a secondary food is not increased by first starving the test animals. Attempts to increase the mean standard intake of a secondary food by adding substances such as raw linseed oil, maize oil, wheat oil, bacon fat oil, coconut oil, various other vegetable oils, and diacetyl were unsuccessful.

Table 5.

SHOWING TEST RESULTS WITH ARSENIC IN PREPARED FOOD.

Rat No.*	Poison Strength.	Poisoned Food. Intake. g.	Poisoned Food. Standard Intake. g./g.	Poison. Intake. mg.	Poison. Standard Intake. mg./kg.	Date Food Offered.	Date of Death.†	Weight (g.), and Sex of Rat (*R. conatus*).	Remarks.
521	1 in 20	0·29	·003	14·5	129·1	Nov. 24	..	106 ; M.	
522	1 in 20	0·86	·007	43·0	350·0	Nov. 24	Nov. 25	123 ; M.	Dead by 9 a.m. Nov. 25.
523	1 in 20	0·82	·007	41·0	343·1	Nov. 24	Nov. 25	119½ ; M.	
524	1 in 20	0·44	·004	22·0	220·0	Nov. 24	Nov. 25	100 ; M.	Died about 4 p.m. Nov. 25.
526	1 in 20	0·47	·005	23·5	252·7	Nov. 24	Nov. 25	93 ; M.	
527	1 in 20	0·98	·009	49·0	437·5	Nov. 24	Nov. 25	112 ; M.	Dead by 9 a.m., Nov. 25.
528	1 in 20	0·69	·008	34·5	420·8	Nov. 24	Nov. 25	82 ; M.	
529	1 in 20	0·44	·005	22·0	226·9	Nov. 24	Nov. 25	97 ; F.	
530	1 in 20	nil	..	..	..	Nov. 24	..	127 ; M.	
531	1 in 20	0·05	·0006	2·5	32·0	Nov. 24	..	78 ; F.	Very sick on Nov. 25; recovered.
532	1 in 20	nil	..	..	..	Nov. 24	..	90 ; F.	
533	1 in 20	0·50	·004	25·0	192·3	Nov. 24	Nov. 25	130 ; M.	Died about 5 p.m., Nov. 25.
534	1 in 20	0·33	·004	16·5	185·4	Nov. 24	Nov. 25	89 ; F.	Dead by 9 a.m., Nov. 25.
R 54	1 in 100	4·07	·034	40·7	339·2	July 19	..	120 ; M.	
R 55	1 in 100	3·94	·038	39·4	380·7	July 19	..	103½ ; F.	
59	1 in 100	3·51	·024	35·1	242·0	July 19	July 20	145 ; M.	
R 60	1 in 100	2·58	·024	25·8	243·4	July 21	..	106 ; F.	
73	1 in 100	6·05	·051	60·5	506·3	July 27	July 29	119½ ; M.	
74	1 in 100	6·65	·082	66·5	816·0	July 27	July 28	81½ ; F.	
R 75	1 in 100	1·36	·013	13·6	133·3	July 27	..	102 ; M.	
82	1 in 100	3·93	·024	39·3	238·9	July 27	..	164½ ; M.	
R 56	1 in 400	4·49	·032	11·2	78·9	July 19	..	142 ; M.	
R 58	1 in 400	3·07	·025	7·7	63·1	July 19	..	122 ; M.	
R 61	1 in 400	0·69	·006	1·7	15·5	July 21	..	110 ; M.	
R 62	1 in 400	2·61	·034	6·5	84·4	July 21	..	77 ; F.	
R 63	1 in 400	11·52	·083	28·8	207·2	July 21	..	139 ; M.	
R 64	1 in 400	3·56	·036	8·9	89·9	July 21	..	99 ; F.	
R 65	1 in 400	1·71	·014	4·3	34·1	July 21	..	126 ; M.	
R 54A	1 in 100	1·71	·014	17·1	142·5	July 26	..	..	Weight 120 g. on 26th ; 112 g. on 27th.
R 54B	1 in 200	3·15	·026	15·75	129·6	Aug. 5	..	121½	
R 54C	1 in 50	1·58	·013	31·0	255·2	Aug. 10	..	..	Weight 117 g. on 11th.
R 55A	1 in 100	5·73	·051	57·3	507·1	July 26	July 27	113	
R 56A	1 in 100	1·56	·010	15·6	104·0	July 26	..	150	
R 56B	1 in 100	2·54	·017	25·4	169·3	July 28	..	..	Weight 130 g. on 28th.
R 56C	1 in 200	0·52	·003	2·6	17·3	Aug. 5	..	..	Weight 133 g. on 6th.
R 58A	1 in 100	1·09	·008	10·9	79·6	July 26	..	137	Weight 129 g. on 27th.
R 58B	1 in 100	0·54	·004	5·4	39·5	July 27	..	..	
R 60A	1 in 400	8·64	·082	21·6	192·5	July 26	..	..	Weight 100½ g. on 26th ; 92 g. on 27th.
R 60B	1 in 200	2·11	·020	10·5	99·1	Aug. 5	..	..	Weight 100 g. on 5th ; 94 g. on 6th.
R 60C	1 in 200	2·72	·023	13·6	116·2	Aug. 10	..	117	
R 60D	1 in 50	2·00	·017	39·2	335·1	Aug. 11	..	..	Weight 93 g. on 11th.
R 60E	1 in 50	1·18	·010	29·0	248·0	Aug. 12	..	..	
R 61A	1 in 100	4·50	·040	45·0	401·8	July 26	..	112	Weight 102 g. on 27th
R 62A	1 in 100	1·92	·021	19·2	207·6	July 26	..	92½	Weight 67½ g. on 27th.
R 63A	1 in 100	4·59	·031	45·9	310·1	July 26	..	148	Weight 137 g. on 27th.
R 64A	1 in 400	4·52	·046	11·3	114·1	July 26	..	..	
R 64B	1 in 100	6·45	·065	64·5	651·6	July 28	July 29	..	
R 65A	1 in 400	2·70	·021	6·75	53·6	July 26	..	..	Weight 120 g. on 27th.
R 65B	1 in 400	3·91	·031	9·77	77·5	July 28	..	..	Weight 122 g. on 28th.
R 65C	1 in 200	0·42	·003	2·1	16·2	Aug. 5	..	129½	Weight 115 g. on 6th.
R 65D	1 in 200	3·09	·022	15·5	112·3	Aug. 10	..	138	Weight 129 g. on 11th.
R 65E	1 in 50	5·03	·036	98·6	714·5	Aug. 11	..	..	Weight 118 g. at 5 p.m. on 11th.
R 65F	1 in 200	0·25	·002	1·25	9·1	Aug. 12	..	..	Weight 104 g. on 13th.

* R before rat number denotes that the specimen will be, or is being, returned for further test. Letter after rat number denotes the return: A for first, B for second, and so on.

† All rats not reported dead were used at later dates for other purposes.

POISONS.

Arsenic (As_2O_3).

According to Wright (1936) the toxicity of As_2O_3 as a rat poison depends somewhat on the fineness of its state of subdivision; when taken in coarse lumps its toxicity is greatly reduced. Munch and Silver (1931), using wild rats and white rats, reported the minimum lethal dose of As_2O_3 (*i.e.*, "the quantity of poison that caused the death of all test animals, or practically all, within the period of five days") to be 100 mg./kg. Other records of As_2O_3 toxicities in rat baits are in the form of amounts of particular baits which will kill rats.

In these experiments a very finely powdered As_2O_3—Merck's reagent quality arsenic trioxide—was used in prepared food. At a poison strength of 1 in 20 the M.L.D., at the initial intake, was 100± 10 mg./kg. and the mean standard intake of poisoned food was ·004± ·0005 g./g. This means that the incorporation of arsenic trioxide depressed food intake by approximately 95 per cent., which supports the observation by Gard (1935) that arsenic with wheat proved quite unattractive to Queensland cane rats.

Table 5 is a series of relevant test results selected at random. Following the intake of sub-lethal doses the arsenic-food intake is still further reduced. A lethal dose during one test period is usually required to cause death.

Reductions in poison strength increase intakes, but the kills are even poorer than at 1 in 20. Figures in Table 5 show that large amounts of arsenic may be taken by some rats in weak poison mixtures, either at one feed or over a period, without causing death.

Appreciable increases in poison strengths above 1 in 20 serve no useful purpose; arsenic-food intakes are often negligible and total kill is decreased.

Using As_2O_3 under optimum conditions—*i.e.*, with the poison mixed in a dry favoured food, and in cages, where the chances of a maximum feed at the first offer are good—a poison intake of not more than twice the M.L.D. can be expected. This is too small a margin to ensure success in the field. The cage experiment results indicate that any degree of success in application control work with this poison will be attained only when it is offered at prebaited feeding stations.

Barium as Barium Carbonate.

Schwartze (1920) remarked that "the literature contains no references to work dealing with the toxicity of barium carbonate to rats, in spite of the fact that many articles give directions for its use as a rat poison and discuss its toxicity to other animals." This author, using *Rattus norvegicus* and administering $BaCO_3$ in starch paste suspension by a stomach tube, found "630 to 750 mg. per kilo . . . . to be the least amount which could be considered efficient," and "the occasional survival of an animal from a large dose would indicate that a 100 per cent. mortality could not be expected." Feeding experiments confirmed these toxicity results and food intakes were such that

Table 6.

SHOWING TEST RESULTS WITH BARIUM CARBONATE IN PREPARED FOOD.

Rat No.*	Poison Strength.	Poisoned Food. Intake. g.	Poisoned Food. Standard Intake. g./g.	Poison. Intake. mg.	Poison. Standard Intake. mg./kg.	Date Food Offered.	Date of Death.†	Weight (g.), and Sex of Rat (*R. conatus*).	Remarks.
R 249	1 in 40	4·91	·062	122·8	1,554·0	Sept. 7	..	79 ; F.	
R 250	1 in 40	3·41	·032	85·3	789·9	Sept. 7	..	108 ; M.	
R 251	1 in 40	4·96	·048	124·0	1,204·0	Sept. 7	..	103 ; F.	
R 252	1 in 20	1·75	·023	87·5	1,136·4	Sept. 7	..	77 ; F.	
R 253	1 in 20	1·25	·011	62·5	563·1	Sept. 7	..	111 ; M.	
R 254	1 in 20	1·92	·020	96·0	980·0	Sept. 7	..	98 ; F.	
255	1 in 20	2·97	·039	148·5	1,928·6	Sept. 7	Sept. 9	77 ; F.	Sick on 8th.
R 246A‡	1 in 10	8·23	·065	823·0	6,480·4	Sept. 14	..	127 ; M.	Weight 114 g. on 14th; 106 g. on 15th.
R 245A‡	1 in 10	2·38	·033	238·0	3,282·0	Sept. 14	..	72½ ; F.	Weight 68½ g. on 15th.
258	1 in 10	3·83	·035	383·0	3,546·3	Sept. 14	Sept. 15	108 ; M.	
269	1 in 5	2·52	·029	504·0	5,727·3	Sept. 22	Sept. 23	88 ; F.	Dead weight 76 g.
270	1 in 5	1·66	·015	332·0	3,018·2	Sept. 22	..	110 ; M.	Weight 90 g. on 23rd; slightly sick.
271	1 in 5	0·71	·006	142·0	1,101·0	Sept. 22	Sept. 23	129 ; M.	Dead weight 127 g.
272	1 in 5	0·94	·008	188·0	1,649·2	Sept. 22	Sept. 23	114 ; M.	Dead weight 110 g.
273	1 in 5	1·05	·013	210·0	2,561·0	Sept. 22	Sept. 23	82 ; F.	Dead weight 81 g.
274	1 in 5	0·69	·007	138·0	1,460·4	Sept. 22	Sept. 23	94½ ; M.	Dead weight 91 g.
R 275	1 in 10	2·93	·030	293·0	3,021·0	Sept. 23	..	97 ; F.	Weight 90½ g. on 24th; slightly sick.
276	1 in 10	1·04	·010	104·0	954·1	Sept. 23	..	109 ; F.	Weight 100 g. on 24th.
R 277	1 in 10	1·84	·022	184·0	2,217·0	Sept. 23	..	83 ; F.	Weight 78½ g. on 24th.
278	1 in 10	0·32	·003	32·0	309·2	Sept. 23	Sept. 24	103½ ; M.	Dead weight 96 g.
279	1 in 10	0·71	·008	71·0	763·4	Sept. 23	Sept. 24	93 ; M.	Dead weight 89 g.
R 280	1 in 10	0·15	·001	15·0	107·1	Sept. 23	..	140 ; M.	Weight 134 g. on 24th.
R 281	1 in 20	0·54	·004	27·0	217·8	Sept. 23	..	124 ; M.	Weight 111½ g. on 24th.
R 282	1 in 20	0·46	·005	23·0	262·9	Sept. 23	..	87½ ; F.	Weight 82 g. on 24th.
286	1 in 20	2·81	·025	140·5	1,248·9	Sept. 23	Sept. 24	112½ ; M.	Dead weight 110½ g.
R 249A	1 in 20	2·76	·033	138·0	1,662·7	Sept. 14	..	83	Weight 79 g. on 15th.
R 250A	1 in 10	0·25	·003	25·0	231·5	Sept. 14	..	..	
R 251A	1 in 20	2·75	·026	137·5	1,322·0	Sept. 14	..	104	
R 252A	1 in 10	2·39	·031	239·0	3,103·9	Sept. 14	Sept. 15	..	
R 253A	1 in 20	3·34	·030	167·0	1,504·5	Sept. 14	..	..	Weight 102 g. on 15th; slightly sick.
R 254A	1 in 10	3·95	·040	395·0	3,950·0	Sept. 14	..	100	Weight 94 g. on 15th.
R 275A	1 in 5	2·59	·026	518·0	5,232·3	Oct. 5	..	99	Weight 92 g. on 6th.
R 275B	1 in 20§	3·10	·032	155·0	1,565·7	Sept. 29	..	..	Weight 93 g. on 29th; 83½ g. on 30th.
R 277A	1 in 40§	2·54	·026	63·5	765·1	Sept. 29	..	..	
R 281A	1 in 5	1·27	·010	254·0	2,048·4	Sept. 29	..	..	Weight 111½ g. on 29th; 106 g. on 30th.
R 282A	1 in 40§	2·54	·029	63·5	725·7	Sept. 29	Sept. 30	..	Weight 84½ g. on 29th; 69 g. on 30th.

* R before rat number denotes that the specimen will be, or is being, returned for further test. Letter after rat number denotes the return : A for first, B for second.

† All rats not reported dead were used at later dates for other purposes.

‡ These return tests are with rats used previously with other poisons.

§ $BaCl_2$ substituted for $BaCO_3$.

it was concluded that "the barium carbonate added to the diet was perfectly palatable." Test animals had been starved for 12 to 24 hours before being fed poison in order to ensure an empty stomach and a sharp appetite.

Wright (1936) considered that $BaCO_3$ is more effective when taken by a hungry animal at the commencement of feeding than if taken later on an already full stomach. Munch and Silver (1931), probably working with

R. norvegicus (starved 12-24 hours), reported 750 mg./kg. for barium carbonate as their comparative toxicity figure. Pemberton (1925) reported cage experiments with $BaCO_3$ mixed dry with rolled oats, wheat flakes, or dry flour in a ratio of one part of poison to 3-6 parts of food. Intake was small and a poor percentage of deaths occurred.

Merck's reagent quality $BaCO_3$ was used in prepared food in the author's experiments, selected results of which are given in Table 6. The figures given in Table 7 illustrate the intake variations which occur with different poison strengths.

Table 7.

SHOWING MEAN STANDARD INTAKES OF BARIUM CARBONATE IN PREPARED FOOD.

Poison Strength.	Mean Standard Intakes (g./g.) of Prepared Food—Barium Carbonate.
1 in 5	·009 ± ·00025
1 in 10	·020 ± ·C047
1 in 20	·021 ± ·0025
1 in 40	·047 ± ·005

After some preliminary tests it became apparent that the rat population being used by the author could be separated into three classes—viz., (*a*) those which could be killed by $BaCO_3$, amounting to approximately 70 per cent.; (*b*) rats which could be poisoned only with considerable difficulty, representing about 22 per cent.; and (*c*) the remaining 8 per cent. which could not be killed with $BaCO_3$ under the conditions of the experiments. A typical example of class (*c*) is rat No. 275 (Table 6). At later dates this rat was given further unweighed food containing $BaCO_3$ at high strengths and survived.

The M.L.D. of barium carbonate for class (*a*) rats is 700± 75 mg./kg. and it does not vary with poison strength to the same extent as does the M.L.D. of As_2O_3. In cages and with poison strengths of from 1 in 3 to 1 in 5 the maximum poison intake attainable using dry prepared food is two to three times the M.L.D. Eskey (1934) has pointed out that "barium carbonate could be used in only 5 per cent. strength with whole grain, as larger amounts would not adhere to the grain." In applied control work, therefore, barium carbonate cannot be used effectively with whole grain. Usually the poison is mixed with grain derivatives and in Queensland canefields barium biscuits have been used. These biscuits consist of one or more grain derivatives mixed with barium carbonate. In the mixing the grain material is wetted with water and then dried, and this reduces the food base bait of a barium biscuit to the status of a secondary food (see page 7) considerably diluted by a large proportion of poison. In cage experiments with barium biscuits, intakes were generally negligible and the few deaths caused by them could be considered as accidental, since in any rat population there is always a small percentage exhibiting abnormal behaviour.

Barium as Barium Chloride.

Wright (1936), in discussing barium carbonate, stated: "It is insoluble in water, and as such is probably non-toxic. It is readily converted, in the presence of dilute hydrochloric acid, into the soluble and highly-toxic barium chloride. Its toxicity depends upon the presence of hydrochloric acid in the stomach . . . ."

Schwartze (1920) using *Rattus norvegicus* and the ordinary crystallized salt, $BaCl_2 \cdot 2H_2O$, found the oral lethal dose to be from 355 g. to 533 g. per kilo. When comparing his barium carbonate and barium chloride toxicity experimental results this author stated: "On the basis of barium content, this preparation of barium carbonate was from 57 to 75 per cent. as potent as barium chloride. In other words, approximately two-thirds of the carbonate was utilised in poisoning the animal."

Table 8 is a selection of test results obtained with Merck's reagent quality $BaCl_2$ in prepared food. At all poison strengths with economic possibilities intakes are poor and irregular. Best results are obtained at a poison strength of 1 in 20 but the M.L.D. of 600 ± 50 mg./kg. is, in many instances, barely covered. As with barium carbonate, many rats do not die after comparatively large intakes of barium chloride.

Table 8.

SHOWING TEST RESULTS WITH BARIUM CHLORIDE IN PREPARED FOOD.

Rat No.*	Poison Strength.	Poisoned Food.		Poison.		Date Food Offered.	Date of Death.†	Weight (g.), and Sex of Rat (*R. conatus*).	Remarks.
		Intake. g.	Standard Intake. g./g.	Intake. mg.	Standard Intake. mg./kg.				
R 241	1 in 50	2·79	·020	54·7	388·0	Sept. 6	..	141; M.	Weight 129½ g. on 7th.
R 242	1 in 50	0·40	·004	8·0	73·4	Sept. 6	..	109; F.	
243	1 in 50	1·30	·011	25·9	223·3	Sept. 6	Sept. 7	116; F.	
R 245	1 in 50	1·19	·017	23·8	330·6	Sept. 7	..	72; F.	Weight 67½ g. on 8th; very sick.
R 246	1 in 50	1·35	·011	27·0	212·6	Sept. 7	..	127; M.	
247	1 in 50	5·64	·074	112·8	1,484·2	Sept. 7	Sept. 8	76; F.	
R 248	1 in 50	3·73	·028	74·6	565·2	Sept. 7	..	132; M.	
288	1 in 20	1·66	·035	83·0	603·6	Sept. 28	Sept. 30	137½; M.	Slightly sick on 29th; accidentally killed.
289	1 in 20	4·95	·040	247·5	2,229·7	Sept. 28	Sept. 30	111; M.	Slightly sick on 29th.
290	1 in 20	1·55	·032	77·5	756·1	Sept. 28	Sept. 30	102½; F.	
291	1 in 20	6·09	·051	304·5	2,719·0	Sept. 28	Sept. 30	112; M.	Very sick on 29th.
292	1 in 20	4·08	·026	102·0	886·9	Sept. 28	Sept. 30	115; M.	
293	1 in 20	5·80	·058	145·0	1,007·0	Sept. 28	Sept. 29	144; M.	
294	1 in 20	5·08	·013	127·0	798·7	Sept. 28	Sept. 30	159; M.	Very sick on 29th.
295	1 in 20	5·41	·032	135·3	1,276·4	Sept. 28	Sept. 29	106; M.	
296	1 in 20	3·11	·017	77·7	653·0	Sept. 28	..	119; M.	
297	1 in 20	5·17	·010	129·3	1,453·0	Sept. 28	..	89; F.	
R 366	1 in 10	0·28	·002	28·0	189·8	Oct. 21	..	147½; M.	
R 367	1 in 10	0·29	·003	29·0	281·6	Oct. 21	..	103; F.	
R 368	1 in 10	2·25	·026	225·0	2,571·0	Oct. 21	..	87½; F.	
369	1 in 10	0·27	·003	27·0	300·0	Oct. 21	..	90; M.	
R 374	1 in 10	2·85	·028	285·0	2,794·1	Oct. 22	..	102; M.	
375	1 in 10	1·12	·013	112·0	1,325·4	Oct. 22	..	84½; F.	
376	1 in 10	2·06	·025	206·0	2,543·2	Oct. 22	..	81; F.	Very sick on 23rd.
R 377	1 in 10	1·00	·012	100·0	1,204·8	Oct. 22	..	83; F.	

* R before rat number denotes return tests with rats used previously with other poisons.

† All rats not reported dead were used at later dates for other purposes.

Schwartze (1920) cited Storer as reporting that "calcium carbonate (whiting) protects rats and mice against barium carbonate as well as lead carbonate poisoning." This author commented that "there is, however, some uncertainty about these experiments, in the absence of definite quantitative poison and food-intake data." Although such references in literature are rare, the concept that on occasions certain foods protect rats from poison is freely discussed by some of these interested in the control of rats in Queensland canefields: $BaCO_3$ is usually associated with these discussions. Although relevant experiments by the author are illustrated in this paper by $BaCl_2$ test results only, rats suitably conditioned exhibit similar behaviour after ingesting $BaCO_3$. Rats fed only on sugar cane during the week previous to testing showed improved intakes of barium but the relatively large intakes of the poison were never lethal. Table 9 is the results of two series: rats Nos. 319-330 reacted normally when fed $BaCl_2$ after a fortnight of dormitory food. The selection of sugar cane as the test material was based on the conversion of $BaCO_3$ to $BaCl_2$ in the rat's stomach and this material provides the largest nightly liquid intake. Similar feeding of rats prior to offering the other poisons used in the experiments does not affect intake of lethal doses.

From cage experimental data it is concluded that $BaCO_3$ and $BaCl_2$ are extremely inefficient rat poisons for use in Queensland canefields.

Table 9.

SHOWING EFFECT OF FEEDING ON SUGAR CANE ON TOXICITY OF BARIUM CHLORIDE IN PREPARED FOOD.

Rat No.	Poison Strength.	Poisoned Food. Intake. g.	Poisoned Food. Standard Intake. g./g.	Poison. Intake mg.	Poison. Standard Intake. mg./kg.	Date Food Offered.	Date of Death.	Weight (g.), Species, and Sex of Rat.	Remarks.
319	1 in 15	8·02	·072	510·3	4,595·0	Oct. 12	..	111; *conatus*; M.	These rats fed on sugar cane only for the week previous to Oct. 12th.
320	1 in 15	2·66	·036	166·3	2,251·8	Oct. 12	..	74; *conatus*; F.	
321	1 in 15	2·62	·027	163·8	1,688·7	Oct. 12	..	97; *conatus*; F.	
322	1 in 15	0·89	·012	55·6	722·1	Oct. 12	..	77; *culmorum*; F.	
323	1 in 15	4·34	·046	271·3	2,886·2	Oct. 12	..	94; *conatus*; M.	
324	1 in 15	4·39	·055	274·4	3,541·6	Oct. 12	..	79½; *conatus*; F.	
325	1 in 30	0·43	·009	13·9	286·6	Oct. 14	..	48½; *M. littoralis*; M.	These rats fed on sugar cane only for the week previous to Oct. 14th.
326	1 in 30	0·41	·003	13·3	110·9	Oct. 14	..	120; *conatus*; M.	
327	1 in 30	4·00	·042	129·1	1,344·8	Oct. 14	..	96; *conatus*; M.	
328	1 in 30	1·83	·019	59·0	627·7	Oct. 14	..	94; *conatus*; M.	
329	1 in 30	3·74	·037	120·6	1,118·2	Oct. 14	..	101½; *conatus*; F.	
330	1 in 30	4·34	·056	141·0	1,831·2	Oct. 14	..	77; *conatus*; F.	

Phosphorus.

No published records of detailed cage experiments with yellow phosphorus as a rat poison are known to the author. Boulenger (1919) stated: "Phosphorus, although obviously easy to detect, proved to be an attractive bait, and far more so than arsenic; unlike the latter, however, it does not, especially in summer, retain its toxic properties for more than a few days." Wright (1936) considered that yellow phosphorus, being insoluble in water, "is absorbed with difficulty and comparatively large quantities can be taken without ill-effect. Absorption is facilitated when it is in a finely-divided state. It is readily soluble in fats and oils and when given in such a medium is highly toxic.'' Montserin (1937) found phosphorus match-heads dissolved in banana to be more efficient against the Trinidad tree rat, in both cage and field trials, than various other poisons, including thallous sulphate. Borden (1941), using ''Rat-nip,'' a commercial phosphorus preparation, at varying concentrations in oats obtained about a 65 per cent. kill, but concluded that ''if rats can be persuaded to eat even a small quantity of a 40 per cent. mixture of Rat-nip in a dry carrier bait, it will be very deadly to them.'' Furthermore, ''the toxicity of Rat-nip seems to be reduced if it is allowed to dry in a thin layer. This is explained by the fact that yellow phosphorus oxidises slowly to red phosphorus (non-poisonous) when exposed to the air.''

Yellow phosphorus as a rat poison is generally used as a paste, for which there are numerous recipes differing only in detail. That of Cilento (1934) for the standard 1 in 112 paste used in Queensland is as follows:—

> ''Phosphorus, 4 oz.; golden syrup, 21 lb.; arrowroot, 3 lb.; flour, 3 lb.; water, 12 oz. Weigh the golden syrup into an enamelled basin. Add the phosphorus quickly, and cover it at once with syrup to prevent it from taking fire. Pour the water on top of the syrup. Heat the mixture carefully to 120 deg. Fahr. in a water bath until the phosphorus is melted. Meanwhile mix the flour and arrowroot together, and, after thorough incorporation, pass the mixture through a fine sieve. When the syrup is heated through and the phosphorus dissolved, remove from the water bath. Stir quickly with a flat wooden spatula, adding the flour mixture gradually. Stir and beat with the spatula in order to divide the phosphorus as finely as possible. Continue to stir and beat the mixture till it is nearly cold, adding any colouring or flavouring which may be desired. Store the mixture when made in airtight tins.''

Pastes made by this method store well. For canefield species cornflour or more flour can be used in place of arrowroot. Garlough (1938) mentioned a fire hazard when using phosphorus compounds as rat poisons. The igniting of phosphorus when spreading poorly made pastes on the bait carrier has been experienced; such happenings are completely eliminated when instructions for making the pastes have been followed carefully and when the pastes are well stirred before using.

Table 10.

SHOWING MEAN STANDARD INTAKES AND KILL OF YELLOW PHOSPHORUS PASTE IN PREPARED FOOD.

Proportion of Phosphorus in Paste.	Ratio of Paste to Food.	Poison Strength.	Mean Standard Intake. g./g.	Percentage Kill.
1 in 112	2 : 5	1 in 395	·004 ± ·0003	100
1 in 250	2 : 3	1 in 625	·0025 ± ·0002	100
1 in 500	1 : 1	1 in 1,000	·006 ± ·001	100
1 in 1,000	1 : 1	1 in 2,000	·020 ± ·003	50

Poison strengths of yellow phosphorus may be varied by altering the proportions of poison in the paste and/or the proportions of pastes mixed with food. Intake depression may be brought about by diluting the favoured food. Intakes of poison in foods poisoned with pastes of various strengths prepared according to Cilento's method are given in Table 10.

Table 11.

SHOWING TEST RESULTS WITH YELLOW PHOSPHORUS PASTE (1 IN 112) WITH PREPARED FOOD.

Rat No.*	Poisoned Food.				Poison.		Date Poisoned Food Offered. (Mixed Oct. 21)	Date of Death.	Weight (g.), and Sex of Rat (*R. conatus*).	Remarks.
	Weight of Prepared Food. g.	Weight of Phosphorus Paste. (1 in 112). g.	Intake. g.	Standard Intake. g./g.	Intake. mg.	Standard Intake. mg./kg.				
355	5·26	2·73	0·27	·002	0·84	5·3	Oct. 21	..	160 ; M.	
356	5·69	2·77	0·81	·006	2·35	16·1	Oct. 21	Oct. 22	146 ; M.	
357	4·53	3·56	0·27	·002	1·05	9·1	Oct. 21	Oct. 22	116 ; M.	
358	5·50	3·78	1·02	·008	3·68	28·9	Oct. 21	Oct. 22	127½ ; F.	
C 42	5·26	2·73	0·46	·007	1·44	21·2	Oct. 22	..	68 ; F.	
C 40	5·69	2·77	0·51	·005	1·48	13·1	Oct. 22	Oct. 24	113 ; M.	Very sick on 23rd.
C 41	4·53	3·56	0·05	·0008	0·195	3·0	Oct. 22	Oct. 24	66 ; F.	
373	5·50	3·78	0·28	·004	1·01	13·3	Oct. 22	Oct. 24	76 ; F.	
C 45A	5·26	2·73	2·44	·046	7·58	141·7	Oct. 25	Oct. 28	53½ ; M.	
366A	5·69	2·77	0·02	·0001	0·58	3·9	Oct. 25	Oct. 26	148 ; M.	
368A	4·53	3·56	1·09	·012	4·24	48·5	Oct. 25	Oct. 26	87½ ; F.	
R 374A	5·50	3·78	Nil	..	..	..	Oct. 25	..	102 ; M.	
370A	5·26	2·73	1·82	·025	5·65	78·5	Oct. 26	Oct. 30	72 ; F.	
381	5·69	2·77	3·65	·055	10·58	160·3	Oct. 26	Oct. 29	66 ; F.	
382	4·53	3·56	2·20	·014	8·59	55·8	Oct. 26	Oct. 29	154 ; F.	
383	5·50	3·78	0·45	·004	1·63	15·1	Oct. 26	Oct. 31	108 ; F.	
C 52	5·26	2·73	0·20	·003	0·62	8·0	Oct. 28	Nov. 2	77½ ; F.	
C 54	5·69	2·77	Nil	..	..	..	Oct. 28	..	149 ; M.	
C 51	4·53	3·56	0·59	·006	2·30	24·2	Oct. 28	Nov. 2	95 ; F.	
401	5·50	3·78	0·29	·004	1·05	13·5	Oct. 28	Oct. 29	78 ; F.	
406	5·26	2·73	0·26	·002	0·81	6·9	Oct. 29	Nov. 4	118 ; M.	
407	5·69	2·77	1·66	·016	4·81	45·0	Oct. 29	Oct. 31	107 ; M.	
408	4·53	3·56	0·27	·027	1·05	10·6	Oct. 29	Nov. 2	99 ; F.	
379A	5·50	3·78	3·09	·049	11·16	177·2	Oct. 29	Oct. 30	63 ; M.	
402A	5·26	2·73	1·20	·015	3·73	46·1	Nov. 3	Nov. 7	81 ; F.	
R 399A	5·69	2·77	0·19	·001	0·55	3·5	Nov. 3	..	159 ; M.	
385A	4·53	3·56	0·49	·007	1·91	26·2	Nov. 3	Nov. 6	73 ; F.	
R 384A	5·50	3·78	0·43	·004	1·55	12·8	Nov. 3	..	121 ; F.	Gave birth to 4 young on 8th.

* R before rat number denotes that the specimen will be, or is being, returned for further test. Letter after rat number denotes the return : A for first.

According to Wright (1936) the action of phosphorus on a rat's system is "similar to that of arsenic, except that it is slower." Phosphorus also resembles arsenic in that the M.L.D. varies somewhat with the poison strength. At a strength of 1 in 2,000 (see Table 10) the M.L.D. is 10 mg./kg., and at strengths most suitable for economic purposes—*i.e.*, from 1 in 200 to 1 in 400—

Table 12.

SHOWING TEST RESULTS WITH YELLOW PHOSPHORUS PASTE (1 IN 112) WITH GRAIN.

Rat No.	Date Offered.	Date of Death.	Time Taken to Die.	Remarks.
Wheat and paste not mixed ; manufactured Oct. 19.				
337	Oct. 19 ..	Oct. 24 ..	$4\frac{1}{2}$–5 days ..	Did not seem to touch poison, but ate most of wheat.
338	Oct. 19 ..	Oct. 23 ..	$3\frac{1}{2}$–4 days ..	
339	Oct. 19 ..	Oct. 23 ..	$3\frac{1}{2}$–4 days ..	
Wheat and paste mixed ; manufactured Oct. 19.				
340	Oct. 19 ..	Oct. 20 ..	Under 12 hours	Negligible take.
341	Oct. 19 ..	Oct. 21 ..	$1\frac{1}{2}$–2 days ..	
342	Oct. 19 ..	Oct. 23 ..	$3\frac{1}{2}$–4 days ..	
343	Oct. 20 ..	Oct. 23 ..	$2\frac{1}{2}$–3 days ..	
344	Oct. 20 ..	..	..	
345	Oct. 20 ..	Oct. 21 ..	Under 12 hours	
346	Oct. 21 ..	..	..	Did not eat.
347	Oct. 21 ..	..	..	
348	Oct. 21 ..	..	..	
349	Oct. 22 ..	..	..	Did not eat.
350	Oct. 22 ..	..	..	
351	Oct. 22 ..	Oct. 23 ..	Under 12 hours	
352	Oct. 23 ..	Oct. 24 ..	12–18 hours ..	
353	Oct. 23 ..	..	..	Did not eat.
354	Oct. 23 ..	..	..	
Wheat and paste mixed on Oct. 18 ; lightly sprayed with linseed oil before each offering.				
362	Oct. 21 ..	Oct. 24 ..	$2\frac{1}{2}$–3 days ..	Both sick on Oct. 23.
363	Oct. 21 ..	Oct. 24 ..	$2\frac{1}{2}$–3 days ..	
364	Oct. 22 ..	..	..	
365	Oct. 22 ..	..	..	
C 67	Oct. 23 ..	..	..	
C 68	Oct. 23 ..	Oct. 28 ..	$4\frac{1}{2}$–5 days ..	
C 69	Oct. 24 ..	..	..	
C 70	Oct. 24 ..	..	..	

it is less than 1 mg./kg. The time elapsing between ingestion of poison and death is of particular importance in experiments with phosphorus as a rat poison. At a poison strength of 1 in 1,000 (as in Table 10) some deaths were recorded 4 to 7 days after poison intakes and at all poison strengths intakes close to the lethal dose may not cause death until as late as 11 days after ingestion. In many instances in cage experiments with phosphorus, deaths occur comparatively quickly despite large depression in food intake when using favoured foods. Actually the negligible takes and small intakes usually allow for a large multiple of the lethal dose and the quick deaths are due to over-dosing. Table 11 illustrates the use of phosphorus paste with a dry ground

Table 13.

SHOWING TEST RESULTS WITH YELLOW PHOSPHORUS PASTE (1 IN 112) ON BREAD.

Rat No.	Date Offered.	Date of Death.	Time Taken to Die.	Remarks.
		Bait manufactured Aug. 2 and tinned.		
170	Aug. 17 ..	Aug. 18 ..	Under 12 hours	Negligible take.
171	Aug. 17 ..	Aug. 18 ..	Under 12 hours	
172	Aug. 17 ..	Aug. 18 ..	Under 12 hours	
173	Aug. 17 ..	Aug. 18 ..	Under 12 hours	
174	Aug. 17 ..	Aug. 18 ..	Under 12 hours	
175	Aug. 17 ..	Aug. 18 ..	Under 12 hours	
		Bait manufactured Aug. 17 and bagged.		
187	Aug. 25 ..	..	..	Did not eat.
188	Aug. 25 ..	Aug. 26 ..	Under 12 hours	Negligible take.
189	Aug. 25 ..	Aug. 26 ..	Under 12 hours	
190	Aug. 25 ..	Aug. 26 ..	Under 12 hours	
191	Aug. 25 ..	..	..	Did not eat.
192	Aug. 25 ..	Aug. 26 ..	Under 12 hours	Negligible take.
		Bait manufactured Aug. 17 and bagged ; in field a day and a night before offering.		
207	Aug. 26 ..	Aug. 29 ..	2½–3 days ..	No apparent take.
208	Aug. 26 ..	Aug. 29 ..	2½–3 days ..	
209	Aug. 26 ..	Aug. 29 ..	2½–3 days ..	
210	Aug. 26 ..	Aug. 27 ..	Under 12 hours	
		Bait manufactured Nov. 25 ; in continuous rain for 24 hours prior to offering.		
546	Nov. 26 ..	Nov. 28 ..	1½–2 days ..	Apparently very poor take.
547	Nov. 26 ..	Nov. 28 ..	1½–2 days ..	
		Bait manufactured Aug. 2 and bagged.		
C.M. 36	Aug. 9 ..	Aug. 10 ..	Under 12 hours	*Melomys littoralis.*
C.M. 46	Aug. 9 ..	Aug. 10 ..	Under 12 hours	

favoured food and Table 12 with or on a whole grain. Examples have been included (Rats Nos. 364, 365, and C.67-C.70, Table 12) of the failure of the addition of linseed oil to increase unfavourable intakes (see page 7).

Table 13 is concerned with paste spread thinly on slices of bread approximately ½ inch thick. Individual baits were made by cutting these slices into dices about ½ inch square.

Phosphorus paste as a rat poison is essentially for use as a snap bait, and in cage experiments it is highly efficient over a wide range of conditions. The choice of a bait base with phosphorus depends on circumstances and, in many instances in Queensland canefields, the use of a favoured food would be unnecessary and wasteful even if practicable. Whole grain is not suitable as a bait base for phosphorus paste as the paste must be well mixed with the food: in the case of bread the thin spread is absorbed sufficiently for this purpose.

Table 14.

SHOWING RETENTION OF TOXICITY BY YELLOW PHOSPHORUS PASTE (1 IN 112) ON BREAD.

Rat No.	Date Offered.	Date of Death.	Time Taken to Die.	Remarks.
	Bait manufactured Nov. 25 ; kept in field until Dec. 20.			
605	Dec. 21 ..	Dec. 26 ..	5 days	
606	Dec. 21 ..	Dec. 24 ..	3 days	
607	Dec. 21 ..	..	..	Did not eat.
	Bait manufactured Nov. 25 ; kept in field until Dec. 20 ; crumbled, and syrup, flour and arrowroot added before offering.			
638	Jan. 25 ..	Jan. 28 ..	$2\frac{1}{2}$–3 days ..	
639	Jan. 25 ..	Jan. 30 ..	$4\frac{1}{2}$–5 days ..	
640	Jan. 25 ..	Jan. 29 ..	$3\frac{1}{2}$–4 days ..	
641	Jan. 25 ..	Jan. 29 ..	$3\frac{1}{2}$–4 days ..	
642	Jan. 25 ..	Jan. 31 ..	$5\frac{1}{2}$–6 days ..	
643	Jan. 25 ..	Jan. 28 ..	$2\frac{1}{2}$–3 days ..	
	Bait manufactured Mar. 23 and bagged ; ground and mixed with prepared food before offering.			
..	Sept. 12 ..	Sept. 14 ..	$1\frac{1}{2}$–2 days ..	
..	Sept. 12 ..	Sept. 17 ..	$4\frac{1}{2}$–5 days ..	
..	Sept. 12 ..	Sept. 17 ..	$4\frac{1}{2}$–5 days ..	
..	Sept. 12 ..	Sept. 15 ..	$2\frac{1}{2}$–3 days ..	
..	Sept. 12 ..	Sept. 20 ..	$7\frac{1}{2}$–8 days ..	
39/430	Oct. 30 ..	..	..	Standard intakes from ·030 g./g. to ·090 g./g.
39/431	Oct. 30 ..	Nov. 2 ..	$2\frac{1}{2}$–3 days ..	
39/432	Oct. 30 ..	Nov. 2 ..	$2\frac{1}{2}$–3 days ..	
39/433	Oct. 30 ..	..	..	
39/434	Oct. 30 ..	Nov. 3 ..	$3\frac{1}{2}$–4 days ..	
39/435	Oct. 30 ..	..	..	
39/436	Oct. 30 ..	..	..	Young born on Nov. 6.
	Bait manufactured Mar. 23 and bagged.			
39/437	Oct. 30 ..	Nov. 3 ..	$3\frac{1}{2}$–4 days ..	
39/438	Oct. 30 ..	..	..	
39/439	Oct. 30 ..	Nov. 1 ..	2 days	
39/440	Oct. 30 ..	Nov. 2 ..	3 days	
39/441	Oct. 30 ..	..	..	

Table 11 also illustrates that phosphorus in prepared food is highly toxic for some days under cage conditions. Table 14, which consists of only a few of the relevant tests made, shows that the toxicity of the phosphorus bait is high for Queensland cane rats over lengthy periods of time. For other animals two examples may be given. Three weeks' old tinned phosphorus-bread baits were carelessly left on the first night of exposure near some 3 months' old chickens. Six died within four hours of picking at these baits. On another occasion three bandicoots were offered 25 phosphorus-bread baits five days after manufacture: although take was poor one weighing 1613 g. died within 12 hours. Where take is negligible and intake is not recorded it is possible that attractiveness and toxicity may have been confused in deciding the reason for non-deaths of rats when offering phosphorus baits. It is suggested that some of the earlier references to the quick loss of toxicity of a bait such as phosphorus-bread may be due to this cause.

Red Squill.

Munch, Silver and Horn (1929) reviewed the literature up to 1929 and supplied considerable cage and laboratory data on red squill. O'Connor, Buck and Fellers (1935) gave details on the standardization of red squill powders and further information on their properties, toxicities, and palatability. These groups of workers used white rats or *R. norvegicus* as test animals and from their observations the salient features of red squill as a rat poison may be stated as follows:—

1. It is generally accepted that squill as a poison is specific to rats. For other animals it is a powerful emetic; in addition, intake by other animals is usually insufficient to provide a lethal dose.
2. "Since red squill powders vary greatly in toxicity, a reliable method for standardising these powders is necessary" (O'Connor *et al.*).
3. "Because the toxic principle of red squill is not known, a chemical procedure as a means of standardising these powders cannot be used. It is necessary to resort to a biological procedure . . . ." (O'Connor *et al.*).
4. "Results obtained in 14 series confirm Claremont's findings that, on the average, less squill powder is required to kill wild rats than is required to kill white rats" (Munch *et al.*).
5. Based on food consumption data for *R. norvegicus,* Munch *et al.* considered squill preparations having a lethal dose at or below 1,000 mg./kg. to be sufficiently toxic for commercial purposes. These workers used 10 per cent. poison concentrations in most instances.
6. "Rats which recover from the effect of sub-lethal doses of red squill powder could rarely be induced to eat squill powder again, even after a lapse of several months. The same animals readily consumed baits containing alcohol or glycerol extracts of red squill" (O'Connor *et al.*).
7. "Red squill powder which has been in storage for 3 years showed no deterioration" (O'Connor *et al.*).

Several authors point out that the sex of the rat is a factor in the toxicity of red squill: it is half as toxic for male as for female rats. Lubitz, Levine and Fellers (1941) recommend "that standard assays of red squill be based on male rats rather than on female rats or rats of mixed sexes."

Three samples of red squill powder were used in the cage experiments, viz.:—

Sample A: Labelled "For Experimental Purposes";

Sample B: A greenish commercial material of French manufacture packed in tins;

Sample C: A commercial line packed in tins.

Munch, Silver and Horn (1929) reported that powder placed in screw-top cardboard mailing tubes for protection from the air, after six months to a year, "solidified into a hard cake, but no change in toxicity could be detected." The three samples used by the author were, when received, of the consistency of hardening putty. Thorough mixing with dry food was difficult. Three years later no appreciable change in toxicities could be detected but the powders had hardened and mixing was still more difficult.

At poison strengths of 1: 50 in prepared food the M.L.D.'s and mean standard intakes of the three samples are as in Table 15.

Table 15.

SHOWING MEAN STANDARD INTAKES OF RED SQUILL POWDERS.

Sample.	M.L.D. mg./kg.	Mean Standard Intake g./g.
A	350 ± 50	·035 ± ·0032
B	550 ± 50	·030 ± ·0047
C	1,000 +	·050 ± ·0049

Neither M.L.D.'s nor kills are improved by mixing 2 per cent. by weight of finely ground glass in the squill poisoned food.

A population of mixed sexes was used as test animals. There was a tendency for males to require slightly larger lethal doses than females but it was not consistent over several series. On the other hand, the lethal dose of any poison for pregnant females, at the peak of virility, was often above the mean.

More detailed work was undertaken with Sample A at poison strengths of 1 in 10, 1: 50 and 1: 75 (see Tables 16 for a selection of series). Over this range the M.L.D. does not alter appreciably. At a strength of 1 in 10 there are always some rats (*e.g.,* Nos. 470, 471, 541 and 542—Table 16) which will not take a lethal dose. Repeat experiments at this strength indicate that an improvement in kill cannot be expected when red squill is repeatedly offered to these rats. Under cage conditions, and using good quality red squill powder (Sample A), a poison intake of not more than twice the M.L.D. can be expected. With the weaker strengths the poison intake is seldom sufficient to induce the symptoms of red squill poisoning—viz., tremors and sensory depression in the hind legs and excessive urination.

Munch, Silver and Horn (1929) reported on the extraction of the toxic principle of red squill with water, alcohol, acetone, and chloroform. Their conclusions were that the toxic principle is soluble in alcohol but not in water, acetone or chloroform, and "it seems evident that the cost of undertaking this on a commercial scale would far outweigh any possible benefit of marketing a more toxic preparation." Buck and Fellers (1935), using methyl and ethyl alcohols as solvents, extracted the toxic principle with Soxhlet apparatus, by stirring,

Table 16.

SHOWING TEST RESULTS WITH POWDERED RED SQUILL IN PREPARED FOOD.

Rat No.*	Poison Strength.	Poisoned Food. Intake. g.	Poisoned Food. Standard Intake. g./g.	Poison. Intake. mg.	Poison. Standard Intake. mg./kg.	Date Food Offered.	Date of Death.†	Weight (g.), and Sex of Rat (*R. conatus*).	Remarks.
129	1 : 50	3·87	·035	75·9	690·0	Aug. 10	Aug. 12	110; F.	Very sick on 11th.
130	1 : 50	6·13	·057	120·2	1,123·4	Aug. 10	Aug. 11	107; F.	
131	1 : 50	4·15	·037	81·4	733·4	Aug. 10	Aug. 11	111; F.	
132	1 : 50	3·49	·037	68·4	727·7	Aug. 10	Aug. 11	94; M.	
203	1 : 50	2·55	·030	50·0	591·8	Aug. 26	Aug. 28	84½; F.	Very sick on 27th.
237	1 : 50	1·78	·021	34·9	405·9	Sept. 2	..	86; F.	
238	1 : 50	5·38	·034	105·5	659·4	Sept. 2	Sept. 4	160; M.	Very sick on 3rd.
467	1 in 10	5·64	·057	564·0	5,697·0	Nov. 11	Nov. 12	99; F.	
468	1 in 10	1·47	·011	147·0	1,122·2	Nov. 11	Nov. 12	131; M.	Died at 1 p.m.
469	1 in 10	1·41	·014	141·0	1,382·4	Nov. 11	Nov. 12	102; M.	Died at 1 p.m.
470	1 in 10	0·14	·001	14·0	133·3	Nov. 11	..	105; M.	
471	1 in 10	0·03	·0004	3·0	36·6	Nov. 11	..	82; F.	
472	1 in 10	0·76	·006	76·0	623·0	Nov. 11	Nov. 12	122; M.	
537	1 in 10	0·32	·002	32·0	222·3	Nov. 26	Nov. 27	144; M.	Weight 129 g. on 27th.
538	1 in 10	0·75	·010	75·0	1,042·0	Nov. 26	Nov. 27	72; F.	Weight 66 g. on 27th.
539	1 in 10	0·43	·004	43·0	361·4	Nov. 26	Nov. 27	119; M.	Weight 106 g. on 27th.
540	1 in 10	0·47	·004	47·0	443·4	Nov. 26	Nov. 27	106; M.	Weight 97½ g. on 27th.
541	1 in 10	0·24	·003	24·0	272·8	Nov. 26	..	88; F.	
542	1 in 10	0·19	·002	19·0	219·7	Nov. 26	..	86½; F.	
R 7	1 : 75	1·28	·011	16·8	138·9	June 22	..	121; M.	
R 7A	1 : 75	3·89	·032	51·2	432·4	June 28	..	..	
R 7B	1 : 75	3·32	·028	43·7	361·4	July 2	..	..	
R 7C	1 : 75	1·16	·009	15·1	124·9	July 7	..	..	
R 7D	1 : 75	2·39	·020	31·4	259·6	July 27	..	..	
R 7F	1 : 75	1·39	·012	18·3	151·3	Aug. 2	..	..	R 7E—sublethal dose of As_2O_3.
R 7G	1 : 75	1·49	·012	19·6	162·1	Aug. 5	..	..	
R 7H	1 : 75	3·26	·027	42·9	354·8	Aug. 10	..	..	Still healthy 1 month later.
R 8	1 : 75	1·66	·016	21·9	210·6	June 22	..	104; M.	
R 8A	1 : 75	1·15	·011	15·1	145·2	June 28	..	..	
R 8B	1 : 75	3·80	·037	50·0	480·8	July 2	..	..	
R 8C	1 : 75	2·96	·028	38·9	374·1	July 7	..	..	
R 8D	1 : 75	2·14	·021	28·2	271·2	July 27	..	..	
R 8E	1 : 75	1·24	·012	16·3	156·7	Aug. 2	..	..	
R 8F	1 : 75	3·45	·033	45·4	436·6	Aug. 5	..	..	
R 8G	1 : 75	4·50	·043	59·3	570·2	Aug. 10	..	..	Still healthy 1 month later.
R 11	1 : 75	2·27	·020	29·9	257·7	June 22	..	116; M.	
R 11A	1 : 75	2·79	·024	36·7	316·4	July 2	..	..	
R 11B	1 : 75	3·45	·030	45·4	391·3	July 7	July 8	..	Weight 88½ g. on 8th.
R 20F	1 : 75	3·95	·022	52·0	287·0	Aug. 5	..	181; M.	R 20A-E–sublethal doses of thallous sulphate.
R 20G	1 : 75	4·49	·025	59·1	326·2	Aug. 10	..	..	
R 20H	1 : 50	1·13	·006	22·2	122·5	Aug. 20	..	..	
R 20J	1 : 50	3·14	·017	61·6	340·0	Aug. 23	..	..	
R 75B	1 : 75	3·04	·029	40·0	392·4	Aug. 2	..	102; M.	
R 75C	1 : 75	4·72	·046	62·1	609·2	Aug. 5	..	..	
R 75D	1 : 75	3·74	·037	49·2	482·7	Aug. 10	..	..	Died from result of accident, Aug. 24th.

* R before rat number denotes that the specimen will be, or is being, returned for further test. Letter after rat number denotes the return: A for first, B for second, and so on.

† All rats not reported dead were used at later dates for other purposes.

and by a percolation method. These authors considered that "the advantages of red squill extract over red squill powder are that extract baits are more palatable and can be readily standardised as to toxicity, and rats will eat the baits repeatedly." Both Munch *et al.* (1929) and Buck and Fellers (1935) dried the extracts, the latter on bran.

The author obtained extract of red squill in alcohol by using a Soxhlet apparatus over a five-hour extraction period. In expressing the poison strength of extract on food the weight of squill powder used to prepare the volume of extract dried on the food is given. For example, in Table 17 a poison strength of 1: 10 indicates that, from an extract (stock solution) prepared with 150 ml. of industrial alcohol and 22·5 g. of Sample A red squill powder, 6·7 ml. of extract have been mixed with and dried on 10 g. of prepared food. In preparing weaker poison strengths alcohol was used to dilute the stock solution. This allows a direct comparison of the toxicity of the extract and the squill powder from which it was prepared. In Table 17 are set out the mean standard intakes for varying poison strengths.

Table 17.

SHOWING MEAN STANDARD INTAKE OF ALCOHOL EXTRACT OF RED SQUILL.

Poison Strength.	Mean Standard. Intake g./g.
1 : 10	·0065 ± ·0015
1 : 20	·010 ± ·0003
1 : 50	·028 ± ·002
1 : 93	·043 ± ·0035
1 : 140	·043 ± ·003
1 : 280	·046 ± ·0005
1 : 560	·051 ± ·004

At a poison strength of 1: 280 the M.L.D. is 100 ± 20 mg./kg., and at 1: 20 there is no appreciable change in this figure. At 1: 10 it is not practicable to establish an M.L.D. direct by using feeding levels as defined by the author. At this strength (the most suitable for control work with the particular powder used) the mean standard intake is approximately six times the probable M.L.D.; intakes are regular when compared with those of poisoned food containing squill powder, and the kill obtained in cages is 100 per cent. The extract may also be used for snap baiting. However, it is necessary to soak the bread in the poison: this is a wasteful method and does not recommend the extract as suitable for snap baiting on a large scale. When using weaker poison strengths, intake following ingestion of sub-lethal doses may be satisfactory.

Satisfactory extracts were also made with powders B and C and industrial alcohol, and with all powders and methylated spirits. All powder residues were tested by drying out and mixing with prepared food in the proportion of 1: 5. Standard intakes were irregular and the M.L.D.'s were 6,000 + mg./kg.

Claremont (1922) reported that the toxic principle from red squill could be extracted with hot water and with cold water. Munch *et al.* (1929) found that the exhaustion of red squill on a steam bath or in a Soxhlet thimble at 100 deg. C. caused almost total removal of the toxic principle. The author soaked Sample A powder in water over varying times and with periodic stirring. Table 18 contains test results of two small series using the aqueous extract from 15 g. of powder in 50 ml. of water for 48 hours. The extract was dried on prepared food in the proportions of 2·5 ml. and 1·5 ml. to 10 g. of food—*i.e.*, the poison strengths referred to the original powders are 1 : 13·3 and 1 : 22·2. Residue tests indicate that the exhaustion was partial only.

Table 18.

SHOWING TEST RESULTS WITH AQUEOUS EXTRACT OF RED SQUILL IN PREPARED FOOD.

Rat No.	Poison Strength.	Poisoned Food. Intake. g.	Poisoned Food. Standard Intake. g./g.	Poison. Intake. g.	Poison. Standard Intake. mg./kg.	Date Food Offered. (Prepared Oct. 11.)	Date of Death.	Weight (g.), and Sex of Rat (*R. conatus*).	Remarks.
40/505	1 : 13·33	1·55	·015	108·2	1,060·5	Nov. 26	Nov. 28	102 ; M.	All sick on 27th.
40/506	1 : 13·33	2·37	·025	164·0	1,744·7	Nov. 26	Nov. 28	94 ; M.	All sick on 27th.
40/507	1 : 13·33	3·67	·037	256·1	2,585·9	Nov. 26	Nov. 28	99 ; M.	All sick on 27th.
40/508	1 : 13·33	3·24	·036	226·1	2,539·4	Nov. 26	Nov. 28	89 ; M.	All sick on 27th.
40/509	1 : 13·33	2·90	·029	202·4	2,044·5	Nov. 26	Nov. 27	99 ; M.	All sick on 27th.
40/510	1 : 13·33	1·36	·015	94·9	1,031·6	Nov. 26	Nov. 27	92 ; F.	
40/511	1 : 22·22	1·04	·014	44·8	581·8	Dec. 11	..	77 ; F.	
40/512	1 : 22·22	2·08	·020	89·6	878·5	Dec. 11	..	102 ; M.	Slightly sick on 12th.
40/513	1 : 22·22	2·28	·017	98·2	711·6	Dec. 11	..	138 ; M.	
40/514	1 : 22·22	1·14	·006	49·1	265·4	Dec. 11	..	185 ; M.	Too old for standard testing.
40/515	1 : 22·22	1·85	·014	79·2	582·4	Dec. 11	..	136 ; M.	
40/516	1 : 22·22	2·23	·020	96·1	850·5	Dec. 11	..	113 ; M.	Slightly sick on 12th.

In Queensland there is no law requiring red squill containers to be labelled with the toxicity of the contents in terms of a standardized bio-assay. This, or some covering arrangement, would be necessary before a poison, with unknown chemical constitution and of such variable toxic content, could be considered for use in large-scale field applications, such as in Queensland canefields.

Strychnine.

Munch and Silver (1931), working with *R. norvegicus,* found that 20-25 mg./kg. killed practically all test animals within a period of five days. Considerable cage work with strychnine and rats has been reported from Hawaii by Pemberton (1925), Barnum (1930) and Borden (1942). These authors pointed out the irregular behaviour of strychnine as a rat poison. Burnett (1932), using the Wyoming ground squirrel *Citellus elegans elegans* as a test animal, found that "the amount of poisoned grain necessary to kill varies so much with individual squirrels that we are unable to decide what should be considered a lethal dose." Wright (1936) stated that rodents are much less susceptible to the action of strychnine than are the carnivora. Gard (1935), using strychnine hydrochloride and strychnine alkaloid at various poison strengths, killed respectively 64 per cent. and 60 per cent. of *R. conatus* in cages. This author considered a poison strength of 1 : 160 as suitable for strychnine on wheat.

In the author's experiments strychnine alkaloid, strychnine sulphate, and strychnine hydrochloride were used with prepared food. As no advantage was gained by using the salts they were discarded at an early date. Table 19 gives mean standard intakes of strychnine alkaloid poisoned food at different poison strengths.

Table 19.

SHOWING MEAN STANDARD INTAKES OF STRYCHNINE.

Poison Strength.	Mean Standard Intake g./g.
1 : 150 to 1 : 225	·018 ± ·002
1 : 500	·022 ± ·002
1 : 1,000	·027 ± ·005

Table 20 is a random selection of test results with strychnine in prepared food. Similar results were obtained when using this poison on wheat in the formula given by Lantz (1918) and adopted by Barnum (1930) against rats.

Deaths, mostly of young animals, may be caused by a strychnine intake as small as 8 mg./kg. On the other hand, a poison intake of 105 mg./kg. at a poison strength of 1: 200 may not kill, and any change from a poison strength approximating closely to 1: 200 does not improve efficiency. Wright (1936) stated that "the chief action (of strychnine) is upon the spinal cord" and the effect of the poison is "characterised by the sudden onset of a tetanic convulsion." He stated also that "the action of strychnine is rather remarkable, in that it is the symptoms which it provokes, rather than a direct toxic action, which are responsible for death." With strychnine poisoning the animal falls on a side and the whole body becomes rigid with the limbs and spine fully extended. The animal after death remains in this position. When clearing test cages during the morning, some rats were found with limbs extended and apparently dead. By afternoon, some of these recovered and seemed normal. Immediate repeat tests resulted in further poison intakes and effects which cannot be correlated with original intakes or previous individual reactions to the poison. There is no evidence that the regular administration of sub-lethal doses of strychnine has an accumulative effect. Furthermore, the intermittent ingestion of varying doses does not indicate that any tolerance exhibited is acquired by previous experience with the poison. In the cage experiments, the immunity to strychnine exhibited by a proportion of the test population was due to intake. Those rats requiring large lethal doses could not be given, by feeding methods at a single test period, a sufficient amount of poison to cause death. As well as the varying effects of strychnine on individuals within a species, there is an additional variation between species. The mean standard intake of strychnine poisoned food by *Melomys littoralis* is considerably higher than that by *Rattus conatus.* At a poison strength of 1: 200 the food intake of *M. littoralis* is depressed by only approximately 50 per cent., but the relatively high intake does not proportionately increase the efficiency of the poison. Deaths occur after poison intakes between 30 mg./kg. and 380 mg./kg. and usually those killed have ingested considerable amounts of strychnine.

Variable and generally poor results can be expected from the use of strychnine as a rat poison in Queensland canefields.

Table 20.

SHOWING TEST RESULTS WITH STRYCHNINE ALKALOID IN PREPARED FOOD.

Rat No.	Poison Strength.	Poisoned Food.		Poison.		Date Food Offered.	Date of Death.	Weight (g.), Species, and Sex of Rat.	Remarks.
		Intake. g.	Standard Intake. g./g.	Intake. g.	Standard Intake. mg./kg.				
156	1 : 1,000	2·13	·024	2·13	23·5	Aug. 17	..	90½ ; *conatus* ; M.	Weight 80½ g. on 18th ; convulsions.
157	1 : 1,000	1·42	·016	1·42	16·0	Aug. 17	..	89 ; *conatus* ; F.	Weight 61 g. on 18th.
158	1 : 1,000	2·71	·023	2·71	23·2	Aug. 17	..	117 ; *conatus* ; F.	Weight 93 g. on 18th.
159	1 : 1,000	4·06	·034	4·06	33·8	Aug. 17	..	120 ; *conatus* ; M.	Weight 110½ g. on 18th.
160	1 : 1,000	7·74	·074	7·47	74·0	Aug. 17	..	101 ; *conatus* ; F.	Weight 94 g. on 18th.
161	1 : 1,000	4·03	·035	4·03	35·4	Aug. 17	..	114 ; *conatus* ; M.	Weight 101 g. on 18th.
162	1 : 1,000	1·58	·014	1·58	14·0	Aug. 17	Aug. 18	113 ; *conatus* ; M.	Weight 107 g. on 18th.
163	1 : 1,000	2·06	·017	2·06	16·9	Aug. 17	..	122 ; *conatus* ; F.	Weight 111 g. on 18th.
165	1 : 1,000	1·80	·016	1·80	16·1	Aug. 17	..	112 ; *conatus* ; M.	Weight 105 g. on 18th.
166	1 : 1,000	3·55	·030	3·55	30·1	Aug. 17	..	118 ; *conatus* ; M.	Weight 113 g. on 18th.
230	1 : 225	0·16	·002	0·70	8·5	Sept. 2	Sept. 3	83 ; *conatus* ; F.	
232	1 : 225	0·13	·002	0·60	7·9	Sept. 2	Sept. 3	76 ; *conatus* ; F.	
234	1 : 225	3·68	·027	16·40	120·6	Sept. 2	Sept. 3	136 ; *conatus* ; M.	
235	1 : 225	1·01	·009	4·50	40·9	Sept. 2	..	110 ; *conatus* ; F.	
237	1 : 225	0·78	·009	3·50	40·7	Sept. 2	..	86 ; *conatus* ; F.	
168	1 : 1,000	1·30	·028	1·30	28·3	Aug. 17	Aug. 18	46 ; *M. littoralis* ; M.	
169	1 : 1,000	4·70	·147	4·70	146·9	Aug. 17	..	32 ; *M. littoralis* ; F.	
170	1 : 1,000	3·31	·114	3·31	114·14	Aug. 20	..	29 ; *M. littoralis* ; F.	
201	1 : 225	3·89	·084	17·29	426·9	Aug. 26	Aug. 27	40½ ; *M. littoralis* ; M.	
231	1 : 225	2·43	·071	10·8	317·7	Sept. 3	Sept. 4	34 ; *M. littoralis* ; F.	

Thallous Sulphate.

Munch and Silver (1931) reviewed all available relevant literature on thallium and also presented results of feeding caged rats with thallium compounds. According to these authors there were very few reports on the action of thallium as a rodent poison prior to 1924 and their more important conclusions, based on literature and experiments, are—

1. The minimum lethal dose of thallous sulphate for wild rats or white rats is 31 mg./kg. with 10 to 20 per cent. error.

2. "Death usually occurs on the second or third day after feeding and is due to respiratory failure."

3. Thallium affects the autonomic nervous system, thereby producing alopecia (loss of hair) and internal disturbances.

4. Thallium is a cumulative poison of high toxicity and is without taste, smell, or other warning properties.

In 1929 Barnum (1930) introduced thallous sulphate into Hawaii and in cage tests found it very satisfactory. The poison was adopted in Javan field practice, Dilliwijn (1932) reporting that 3-5 mg. were sufficient to kill the Java field rat. Barnett (1935) stated that 4½ mg. of thallous sulphate would kill a rat (*R. conatus,* incorrectly called *R. culmorum,* and with an average adult weight of 125 g.).

Using B.D.H. thallous sulphate in varying proportions in prepared food, the mean standard intakes given in Table 21 were recorded. Similar intakes were recorded when wheat was substituted for prepared food. To prepare thallous sulphate treated wheat, a weighed quantity of thallous sulphate is

Table 21.

SHOWING MEAN STANDARD INTAKES OF THALLOUS SULPHATE.

Poison Strength.	Mean Standard Intake g./g.
1 : 3,000	·068 ± ·0045
1 : 1,000	·067 ± ·0055
1 : 500	·038 ± ·003
1 : 300	·037 ± ·003
1 : 250	·029 ± ·0017
1 : 100	·028 ± ·002
1 : 50	·027 ± ·002
1 : 25	·025 ± ·002

dissolved in the minimum volume of hot to boiling water; this is quickly poured over and stirred into the weighed wheat, which is then spread out to dry. The intakes of wheat treated in this manner are similar to those of poisoned wheat prepared by the modified thallium sulphate-wheat formula of Barnum (1930, p. 438). Furthermore, when samples prepared by each method are shaken vigorously for 20 minutes in tins, then screened and analysed, no significant loss of thallium is shown. On occasions commercial thallous sulphate treated wheat was used in tests. The poison strength of these bulk preparations was invariably lower than that claimed on the label: *e.g.,* samples from containers labelled 2 lb. of thallous sulphate to 2,000 lb. of wheat on chemical analysis showed poison strengths from 1:1,100 to 1:1,200. In all test calculations with these materials poison strengths based on chemical analyses were used.

For all poison strengths the M.L.D. of thallous sulphate is 30 ± 3 mg./kg. It is a very reliable poison and only occasionally does a rat, usually a large and virile male (see rat No. R20F, Table 22) or a pregnant female, live after an intake of 50 mg./kg. The accumulative action of the poison depends on a time x dosage factor. Doses less than 20 mg./kg. given on successive nights over a six-day period will not kill. The animal can apparently eliminate from its system sufficient of the poison in a 24-hour period to keep alive. If one of the doses during any night exceeds 20 mg./kg. death usually occurs. With intermittent feeding an occasional poison intake approaching the lethal dose can be

Table 22.

SHOWING TEST RESULTS WITH THALLOUS SULPHATE IN PREPARED FOOD.

Rat No.*	Poison Strength.	Poisoned Food.		Poison.		Date Food Offered.	Date of Death.	Weight (g.), and Sex of Rat (*R. conatus*).	Remarks.
		Intake. g.	Standard Intake. g./g.	Intake. mg.	Standard Intake. mg./kg.				
R 13	1 : 3,000	6·66	·063	2·22	20·9	June 22	..	106 ; M.	
R 13A	1 : 3,000	4·83	·046	1·61	15·2	June 28	..	..	
R 13B	1 : 3,000	6·71	·063	2·24	21·1	July 2	..	..	
R 13C	1 : 2,000	6·90	·065	3·45	32·5	July 8	..	..	
R 13D	1 : 1,000	4·00	·038	4·00	37·7	July 13	..	..	
R 13E	1 : 1,000	1·20	·011	1·20	11·3	July 15	July 16	..	Weight 78 g. on 16th.
R 15	1 : 3,000	8·19	·065	2·73	21·7	June 22	..	126 ; M.	
R 15A	1 : 3,000	0·77	·006	0·26	2·1	June 28	..	..	
R 15B	1 : 3,000	1·10	·009	0·37	2·9	July 2	..	..	
R 15C	1 : 2,000	6·52	·052	3·26	25·9	July 3	..	..	
R 15D	1 : 1,000	4·40	·035	4·40	34·9	July 13	..	..	
R 15E	1 : 1,000	Nil	Nil	Nil	Nil	July 15	..	..	
R 15F	1 : 1,000	1·50	·012	1·50	11·9	July 19	July 21	..	Weight 91 g. on 21st.
R 17	1 : 3,000	12·48	·089	4·16	29·5	June 22	..	141 ; M.	
R 17A	1 : 3,000	5·89	·042	1·96	13·9	July 2	..	..	
R 17B	1 : 1,000	6·05	·043	6·05	42·9	July 8	..	..	
R 17C	1 : 1,000	6·45	·046	6·45	45·8	July 13	July 14	..	Weight 112½ g. on 14th.
R 18	1 : 3,000	8·10	·072	2·70	23·9	June 22	..	113 ; M.	
R 18A	1 : 3,000	6·90	·061	2·30	20·3	July 2	..	..	
R 20	1 : 3,000	6·72	·044	2·24	14·7	June 28	..	152 ; M.	
R 20A	1 : 2,000	7·68	·051	3·84	25·3	July 2	..	..	
R 20B	1 : 2,000	2·59	·017	1·30	8·5	July 7	..	..	
R 20C	1 : 1,000	5·15	·030	5·15	30·0	July 13	..	171½ ;	
R 20D	1 : 1,000	2·50	·015	2·50	14·6	July 15	..	..	
R 20E	1 : 500	3·27	·019	6·54	38·1	July 19	..	..	
R 20F	1 : 500	4·43	·025	8·86	50·6	July 27	..	175	*See* also Table 16.
R 37	1 : 1,000	8·61	·085	8·61	85·3	July 12	..	101 ; M.	
R 37A	1 : 1,000	5·64	·056	5·64	55·9	July 15	July 16	..	Weight 84½ g. on 16th.
R 38	1 : 1,000	10·30	·067	10·30	67·1	July 12	..	153½ ; F.	Gave birth to 5 young on 12th.
R 38A	1 : 1,000	4·60	·030	4·60	30·0	July 15	July 17	..	
R 39	1 : 1,000	12·07	·094	12·07	94·3	July 12	July 14	128 ; M.	
R 40	1 : 1,000	8·00	·086	8·00	86·0	July 12	..	93 ; M.	
R 40A	1 : 1,000	3·30	·036	3·30	35·5	July 15	July 20	..	Weight 65 g. on 20th.
R 41	1 : 1,000	6·30	·065	6·30	65·0	July 12	..	97 ; M.	
R 41A	1 : 1,000	2·80	·029	2·80	28·9	July 15	July 16	..	Weight 77½ g. on 16th.
R 43	1 : 1,000	9·80	·084	9·80	83·8	July 12	..	117 ; F.	
R 43A	1 : 1,000	Nil	Nil	Nil	Nil	July 15	July 16	..	Weight 100½ g. on 16th.
R 44	1 : 1,000	5·2	·036	5·20	35·6	July 12	..	146 ; F.	
R 44A	1 : 1,000	3·17	·021	3·17	21·0	July 15	July 17	..	Weight 109 g. on 17th.
48	1 : 1,000	9·22	·096	9·22	96·0	July 19	July 23	96 ; M.	
49	1 : 1,000	5·67	·079	5·67	78·7	July 19	July 23	72 ; M.	Young for test.
50	1 : 1,000	5·78	·065	5·78	64·6	July 19	July 23	89½ ; M.	
51	1 : 1,000	5·20	·063	5·20	63·1	July 19	July 23	82½ ; M.	Young for test.
52	1 : 1,000	7·25	·057	7·25	56·9	July 19	July 23	127½ ; M.	
53	1 : 1,000	6·85	·050	6·85	50·4	July 19	July 22	136 ; M.	
2	1 : 300	4·72	·031	15·7	101·6	June 14	June 20	154½ ; M.	
3	1 : 300	5·62	·036	18·7	121·1	June 14	June 17	154½; M.	
4	1 : 300	4·12	·040	13·7	133·0	June 14	June 16	103 ; M.	
5	1 : 300	3·55	·024	11·8	80·8	June 14	June 18	146 ; M.	
6	1 : 300	5·84	·035	19·5	115·4	June 14	June 17	169 ; M.	
804	1 : 50	7·52	·031	147·5	602·0	Sept. 19	Sept. 21	245 ; M.	
805	1 : 50	1·38	·017	27·1	334·6	Sept. 19	Sept. 21	81 ; M.	Young for test.
806	1 : 50	2·82	·024	55·3	462·1	Sept. 19	Sept. 21	118 ; M.	
808	1 : 50	6·02	·032	118·0	638·0	Sept. 19	Sept. 21	185 ; M.	
809	1 : 50	2·16	·018	42·4	353·4	Sept. 19	Sept. 21	120 ; F.	
810	1 : 25	5·21	·033	200·4	1,268·4	Sept. 19	Sept. 20	158 ; M.	
811	1 : 25	2·65	·031	101·9	1,191·9	Sept. 19	Sept. 20	85½ ; M.	Young for test.
812	1 : 25	2·02	·028	77·0	1,069·5	Sept. 19	Sept. 20	72 ; M.	
813	1 : 25	3·30	·025	127·0	955·0	Sept. 19	Sept. 21	133 ; M.	
814	1 : 25	1·61	·016	62·0	608·0	Sept. 19	Sept. 21	102 ; M.	
815	1 : 25	3·01	·030	115·8	1,158·0	Sept. 19	Sept. 20	100 ; M.	

* R before rat number denotes that the specimen will be, or is being, returned for further test. Letter after rat number denotes the return : A for first, B for second, and so on.

eliminated by the animal. The sum of poison intakes on successive nights may be greater than the M.L.D. without death occurring (see Rat No. 18, Table 22). (A bandicoot, *Perameles nasuta*, weighing 1,216 g. ate 40 g. of 1: 500 thallous sulphate-wheat on each of five successive nights; death occurred on the sixth night.)

Table 23.

SHOWING TEST RESULTS WITH THALLOUS SULPHATE, FED ON TWO CONSECUTIVE NIGHTS.*

Rat No.†	Poison Strength.	Poisoned Food. Intake. g.	Poisoned Food. Standard Intake. g./g.	Poison. Intake. mg.	Poison. Standard Intake. mg./kg.	Date Food Offered	Date of Death.	Weight (g.), and Sex of Rat (*R. conatus*).	Remarks.
R 644	1 : 500	4·43	·037	8·84	74·3	Feb. 3	..	119; M.	
R 645	1 : 500	6·28	·050	12·54	99·1	Feb. 3	..	126½; M.	
R 646	1 : 500	4·74	·046	9·46	91·0	Feb. 3	..	104; M.	
R 647	1 : 500	3·32	·037	6·63	74·1	Feb. 3	..	89½; F.	
R 648	1 : 500	5·61	·057	11·20	114·3	Feb. 3	..	98; F.	
R 649	1 : 500	4·50	·046	9·00	91·9	Feb. 3	..	98; M.	
R 650	1 : 500	4·50	·043	9·00	86·2	Feb. 3	..	104½; F.	
R 651	1 : 500	4·03	·050	8·05	99·4	Feb. 3	..	81; F.	
R 652	1 : 500	4·49	·045	8·96	89·2	Feb. 3	..	100½; M.	
R 644A	1 : 500	0·46	·004	0·92	7·7	Feb. 4	Feb. 6	..	
R 645A	1 : 500	4·72	·037	9·42	74·5	Feb. 4	Feb. 6	..	
R 646A	1 : 500	4·81	·046	9·60	92·4	Feb. 4	Feb. 6	..	
R 647A	1 : 500	0·70	·008	1·40	15·7	Feb. 4	Feb. 6	..	
R 648A	1 : 500	5·64	·058	11·26	115·0	Feb. 4	Feb. 5	..	
R 649A	1 : 500	5·37	·055	10·72	109·4	Feb. 4	Feb. 6	..	
R 650A	1 : 500	0·45	·004	0·90	8·6	Feb. 4	Feb. 6	..	
R 651A	1 : 500	0·61	·008	1·22	15·1	Feb. 4	Feb. 6	..	
R 652A	1 : 500	0·72	·007	1·44	14·3	Feb. 4	Feb. 6	..	
R 714	1 : 250	3·14	·032	12·5	126·3	Mar. 14	..	99; M.	
R 715	1 : 250	2·97	·029	11·8	115·2	Mar. 14	..	102½; M.	
R 716	1 : 250	2·39	·022	9·5	88·0	Mar. 14	..	108; M.	
R 717	1 : 250	4·57	·035	18·2	137·9	Mar. 14	..	132; M.	
R 718	1 : 250	3·69	·032	14·7	129·0	Mar. 14	..	114; M.	
R 719	1 : 250	2·90	·037	11·5	145·6	Mar. 14	..	79; M.	Too young for standard intake test.
R 714A	1 : 250	1·51	·015	6·0	60·6	Mar. 15	Mar. 17	..	
R 715A	1 : 250	1·20	·012	4·8	46·6	Mar. 15	Mar. 17	..	
R 716A	1 : 250	0·52	·005	2·1	19·5	Mar. 15	Mar. 17	..	
R 717A	1 : 250	0·99	·008	3·9	29·5	Mar. 15	Mar. 17	..	
R 718A	1 : 250	1·32	·012	5·3	46·5	Mar. 15	Mar. 17	..	
R 719A	1 : 250	0·41	·008	1·6	20·3	Mar. 15	Mar. 17	..	
R 744	1 : 100	4·19	·037	41·5	367·3	Mar. 22	..	113; M.	
R 745	1 : 100	2·30	·013	22·8	131·4	Mar. 22	..	173½; M.	Too old for standard intake test.
R 746	1 : 100	3·44	·030	34·1	294·0	Mar. 22	..	116; M.	
R 747	1 : 100	4·96	·035	49·1	350·7	Mar. 22	..	140; M.	
R 748	1 : 100	3·35	·030	33·2	297·8	Mar. 22	..	111½; M.	
R 749	1 : 100	3·23	·027	32·0	272·4	Mar. 22	..	117½; M.	
R 744A	1 : 100	Nil	..	..	..	Mar. 23	Mar. 25	..	} Very sick on 24th.
R 745A	1 : 100	Nil	..	..	..	Mar. 23	Mar. 25	..	} Very sick on 24th.
R 746A	1 : 100	Nil	..	..	..	Mar. 23	Mar. 24	..	
R 747A	1 : 100	Nil	..	..	..	Mar. 23	Mar. 24	..	
R 748A	1 : 100	Nil	..	..	..	Mar. 23	Mar. 25	..	Very sick on 24th.
R 749A	1 : 100	Nil	..	..	..	Mar. 23	Mar. 24	..	

* Bait base was prepared food for poison strength of 1 : 500, and whole wheat for other strengths.

† R before rat number denotes that the specimen will be, or is being, returned for further test. Letter after rat number denotes the return: A for first.

Gross symptoms of thallous sulphate poisoning are general depression, loss of muscular control in the hind legs, and watery eyes. Unlike the symptoms of red squill and strychnine poisoning, once those of thallium are apparent death is inevitable. The visible sign of continued sub-lethal dosing is alopecia. These gross symptoms usually become apparent closer to the time of death than to the time of ingestion of the lethal dose. Rats generally die on the third day following lethal ingestion, occasionally they die on the second day, and sometimes they live for five days after the intake of the lethal dose (see Tables 22 and 23). Between the ingestion of the lethal dose and the onset of gross symptoms rats may feed more or less in a normal manner: this phenomenon, exhibited to any extent only with thallium poisoning, is termed secondary feeding. With sub-lethal intakes and secondary feeding at a poison strength of 1:1,000 approximately 75 per cent. of poison intake is waste and is of little importance in increasing percentage kill in test cages. The elimination of wastage of poison without lessening kill, and the correlating of total poisoned food intake with efficiency, involve a consideration of both initial poison intake and the amount of secondary feeding. Table 23, in which are tabulated some results of tests on two consecutive nights, indicates that secondary feeding under cage conditions is eliminated when a poison strength of 1:100 is used; but the initial intake of poison is large. Cage experiments show that the most economical and efficient poison strength for thallous sulphate treated favoured food is between 1:500 and 1:100: a more specific strength for field use can be nominated only by field tests with known rat populations.

Thallous sulphate is an outstanding rat poison for use in food baits.

A proprietary paste, which by analysis contained 2·5 per cent. of thallium, and two prepared pastes containing 5 per cent. and 10 per cent. thallous sulphate, were used with bread and bran. Negligible takes were recorded and kill was poor. It is concluded that thallous sulphate in paste form is not suitable for use in snap baits.

Miscellaneous.

The oily liquid, glycerol monochlorhydrin, was found to be insufficiently toxic for use with whole grain.

Only preliminary experiments were undertaken using zinc phosphide. This chemical had not been used as a rat poison in Queensland canefields and it did not compare favourably with thallous sulphate.

Sulphurised linseed oil (R. B. Harvey), sulphur, naphthalene, creosote, and dieseline were tried as repellants by either spraying, painting, or dusting the materials on sugar cane supplied in inhabited living cages. All canes so treated were eaten, although some of the rats attacking the creosote-sprayed canes were poisoned.

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