rest of the organ reproduced itself. What would seem to prove it is the fact that, as I have said in speaking of No. 3, the dorsal fin increased in size on account of the use he made of it to replace the amputated caudal fin.

A. DUGÈS.

GUANAJUATO, MEXICO,
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LABORATORY EXPERIMENTS WITH CS_2 TO DETERMINE THE LEAST AMOUNT OF GAS AND THE LEAST TIME REQUIRED TO KILL CERTAIN INSECT REPRESENTATIVES OF VARIOUS FAMILIES.[1]

WHILE a sufficiently large series of insects has not yet been worked upon to draw a definite conclusion upon the above point, the following paper is submitted as showing some interesting results incident to this work. Experiments were begun in California a few years ago, and continued for a time in Minnesota. Three hundred and eighty-six insects have been tested. Of this number some have not been included in the tables, where the record was not regarded as sufficiently complete.

The points which might be brought out by an exhaustive series of observations in this line are as follows: Least strength required with a minimum expenditure of time to kill (*a*) insects in general, (*b*) particular groups, safety to foliage being understood; effect of moisture upon results; effect of temperature upon results; expense of material for effective use upon a known number of plants, trees, insect colonies or stored products, what per cent., if any, succumbed after seeming recovery; beginning effects of gas upon (*a*) insects in general, (*b*) groups in particular; significance of occasional spasmodic movements of legs, wings, sometimes long after apparent death; corroboration of laboratory results with results from the field as far as possible; different results with different brands of CS_2; corroboration with previous published statements.

Method and Apparatus Described; Computation.—The necessary crudity of the apparatus and method described is evident, and must render the results in the case of insects of any size not even approximate. An insect as large as *Ectobia,* or *Apis mellifica,* for example, or the larva of the western peach-tree borer, or that of the Mediterranean flour moth, evidently displaces so much of the gaseous contents of a vial when introduced, as to render absurd the proportions of gas to atmosphere as given. Even in insects smaller than these there is undoubtedly an error due to displacement, yet the writer believes that the method described here comes as near demonstrating facts in this connection as possible, particularly in the case of very small insects, and it has certainly brought out interesting results, from which we may select what appears authentic.

A large number of homeopathic vials were secured, of the same size (homeopathic 2 gram vial No. 1,657 with patent lip), also pieces of flexible rubber piping of such a size as to fit tightly over these vials. Into one vial a drop of CS_2 was allowed to fall from a medicine dropper, and the mouth of this vial immediately placed against the mouth of another empty vial, the rubber tubing referred to serving to hold the two vials closely together, and preventing any egress of gas, or entrance or exit of atmosphere.

The average capacity of these vials was 8.7 c.c., and it was upon this basis that our calculations were made. The volume of gas coming from one drop of CS_2 equaled 4.35 c.c., and, therefore, filled half a vial.

It is evident, therefore, that the union of the first two bottles, made immediately, before the gas had an opportunity of driving out any of the atmosphere, caused a mixture of one part of gas to four of atmosphere; the second change, one to eight; the third, one to sixteen; the fourth, one to thirty-two, etc., or, interpreting it with reference to the liquid volume of CS_2 to the atmosphere, we find that the union of the first two bottles equaled one part of liquid CS_2 to 1,494 parts of atmosphere, or in round numbers, 1,500 parts of atmosphere; the second change, one part of liquid CS_2 to 2,988 parts of atmosphere, or in round num-

[1] Abstract of paper read before the Association of Economic Entomologists at Philadelphia at their last annual meeting.

bers 3,000 parts of atmosphere; the third change, one part of liquid CS_2 to 6,000 parts of atmosphere; the fourth change, one part of liquid CS_2 to 12,000 parts of atmosphere, and so on.

The greatest pains were taken to secure volatilization of the liquid. Nearly half an hour was allowed to elapse after the drop was enclosed before changing bottles, and no change was made as long as the slightest evidence of the liquid CS_2 was observed.

Now then, it is evident that if our calculations are correct, we could by placing it in an empty vial, and then applying it as above described to one of the vials containing a mixture of gas and atmosphere, expose an insect to any desired proportion of gas and atmosphere.

One hundred and fifty-six specimens of coleoptera (largely composed of *Tribolium confusum*) were treated, of which fifty-eight were entered in tables as offering authentic results. Experiments with fifty-two diptera were tabulated, as were also experiments with fifty-six hemiptera (mostly aphids). Forty lepidopteran larvæ were used and results tabled, and thirty-one hymenoptera. A few entries in the tables are here given as an example of the method employed, and at the same time offering an illustration of the somewhat remarkable vitality of the Aphidæ.

No.	Name.	Strength.	Exposure. hr. m.	Died.	Recovered.
31	Aphid.	1–24,000	27		9 minutes—died later.
32	"	1–24,000	25		41 "
33	"	1–24,000	20	Yes.	
94	"	1–12,000	2 4	"	
123	Mealy Bug.	1–12,000	50		2 hours 20 minutes.
124	" "	1–12,000	54	"	
125	" "	1–24,000	1 8	"	
126	" "	1–24,000	1 12		Next A.M.
127	" "	1–24,000	28	"	
128	" "	1–48,000	1 20	"	
129	" "	1–48,000	2 38	"	
130	" "	1–48,000	1 7		
131	" "	1–24,000	15	"	
132	Aphid ad. wgl.	1–24,000	14		4 hours 25 minutes.
133	" juv.	1–24,000	14		4 " 25 "
134	" "	1–24,000	13		4 " 25 "
135	" "	1–24,000	13		4 " 25 "
136	" "	1–24,000	12		4 " 25 "
137	" "	1–24,000	12		4 " 25 "
138	" "	1–24,000	11		4 " 25 "
139	" "	1–24,000	11		4 " 25 "
140	" ad. wgl.	1–48,000	1 42		1 hour 18 "
141	" "	1–48,000	44		1 " 7 "
142	" juv.	1–48,000	1 42	"	
143	" "	1–48,000	1 38	"	
144	" "	1–48,000	1 41		1 " 7 "
145	" "	1–48,000	1 40		2 hours
146	" "	1–24,000	1 8	"	
147	" "	1–24,000	1 8		Next A.M.
148	" "	1–24.000	2 21	"	
149	" "	1–24,000	2 30	"	
150	" "	1–24,000	2 22	"	
151	" "	1–48,000	2 12	"	
152	" "	1–48,000	2 08	"	

Conclusions.—The experiments demonstrate that it is very much easier to kill diptera than coleoptera. It is further to be noted that insects are apparently dead long before death actually occurs. I have no doubt but that there is an immediate effect upon the individual insect coming in contact with the gas, although it does not always show this. By 'effect' as noted in the tables, we mean the first marked uneasiness on the part of the insect under treatment. In some cases this effect is immediate.

It is to be also noted in this particular that in the case of many specimens the first noticeable effect was an attempt on the part of the insect to clean its antennæ. The striking individual variations, in other words, the revival of many subjects after apparent death, show the necessity of extreme thoroughness in field and greenhouse, that is, a long enough exposure to insure carrying the insect beyond all possibility of recovery.

One hour's exposure to one part liquid CS_2 to 12,000 parts of atmosphere is apparently sufficient to kill aphids, but in making suggestions for practical application, I should certainly urge an hour and a half's exposure to that strength as being more sure, especially with crude CS_2. Ants appear generally to succumb to one hour's exposure to one part liquid CS_2 to 12,000 parts of atmosphere, the same as aphids, and yet in actual practise, to insure the best results, they should be subjected to a longer treatment. Aphids show immediately the effect of exposure, and some were on their backs from two to four minutes after treatment, and yet recovered after an exposure of three fourths of an hour to one part liquid CS_2 to 12,000 parts of atmosphere. *Tribolium confusum* was observed particularly to clean the antennæ immediately upon exposure.

The remarkable vitality of the Aphidæ (insects that we commonly regard as extremely delicate) is to be noted in connection with this work. Further, in a few cases we found that some of the insects which recovered such treatment died later, say within twenty-four hours, although the bottles in which they were confined were left open, only slightly plugged with absorbent cotton. This 'apparent death' is very deceiving. To all appearances these insects were absolutely dead, perfectly motionless, and in many cases we entered them on the record as dead, although we had to change that record several minutes later, when a wing, a leg or an antenna would be seen to move. Frequently only a slight movement of the mouth parts, all other appendages being quiescent, would indicate that the insect treated was still alive.

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A NOTE ON THE CALCULATION OF CERTAIN PROBABLE ERRORS.

THE purpose of this note is to call the attention of workers in biometry to a point which serves to lessen somewhat the labor of computation in the frequently arising cases when one wishes to test whether a given frequency distribution obeys the normal law. Though sufficiently obvious, the point seems not to have been noticed.

In determining whether a given distribution of frequency follows the normal or Gaussian law it has been shown by Pearson[1] that the important constants are

$$\sqrt{\beta_1} = \sqrt{\frac{\mu_3^2}{\mu_2^3}},$$

$$3 - \beta_2 = 3 - \frac{\mu_4}{\mu_2^2},$$

$$\text{the skewness} = \tfrac{1}{2}\,\frac{\sqrt{\beta_1}(\beta_2 + 3)}{5\beta_2 - 6\beta_1 - 9},$$

and the 'modal divergence,'

$$d = \text{skewness} \times \sigma.$$

All these constants should equal zero within the limits of the error due to random sampling if the distribution be truly normal.

The probable errors concerned are (for the normal distribution), when $N =$ the total number of individuals,

$$\text{Probable error of skewness} = .67449\sqrt{\frac{3}{2N}}, \quad \text{(i)}$$

$$\text{Probable error of } \sqrt{\beta_1} = .67449\sqrt{\frac{6}{N}}, \quad \text{(ii)}$$

$$\text{Probable error of } \beta_2 = .67449\sqrt{\frac{24}{N}}, \quad \text{(iii)}$$

$$\text{Probable error of } d = .67449\sqrt{\frac{3}{2N}}\cdot\sigma. \quad \text{(iv)}$$

It is at once clear that the values of expressions (i), (ii) and (iii) stand in the relation to each other of

$$1 : 2 : 4.$$

[1] *Biometrika*, Vol. 4, pp. 169–212.