

## The Thermal Death Point of *Callosobruchus maculatus* (Fabricius)

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### ABSTRACT

A thermal death point of 51.5°C for 15 minutes exposure and 47.5°C for 4 hours exposure was determined for *Callosobruchus maculatus* F. Weight loss was lower at higher humidities. Death after 12 hours exposure at 46°C was due to both high temperature and the loss of moisture by evaporation, and is therefore not regarded as a true thermal death point.

### INTRODUCTION

*Callosobruchus maculatus* F. (Coleoptera: Bruchidae) is a very important pest of stored cowpeas, *Vigna unguiculata*, in Nigeria. Infestation starts in the field on mature pods and continues in storage (Caswell, 1970). *C. maculatus* has been known to develop at temperatures between 17°C and 37°C (Howe and Currie, 1964). Below this temperature – range, hatching is deterred, while at higher temperatures, the eggs, larvae and pupae are killed. Taylor (1974) reported that development above 30°C aided the production of “active” forms.

In this paper the highest possible temperature at which adult *C. maculatus* can survive has been determined at various humidity levels.

### MATERIALS AND METHODS

Relative humidities of 0%, 30%, 60%, 90% and 100% were created in boiling tubes (17cm x 2cm), using different concentrations of sodium hydroxide as described by Buxton (1931) and Madge (1961). These were checked using medium thiocyanate paper, as described by Solomon (1945) in a Lovibond humidity test Kit.

Five day-old females of *C. maculatus* were weighed and put in hollow glass tubing (4cm x 1cm), which was covered at both ends with fine nylon mesh. These were suspended 1cm above the aqueous solutions of sodium hydroxide in boiling tubes maintained at 0%, 30%, 60%, 90% and 100% r.h. The same procedure was followed for the males. The experimental design was a randomised block with five replicates. The boiling tubes were immersed neck deep in a thermostically controlled water bath as described by Madge (1965) for oribatid mites. The apparatus was kept at temperatures ranging from 40°C, 41°C, 42°C, 43°C, 44°C, 45°C, 46°C, 47°C, 48°C, 49°C,

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50°C, 51°C, 52°C to 53°C for 15 minutes to equilibrate before starting the experiment. Temperature was constantly checked using a thermometer, held 1cm above distilled water in a boiling tube, as was done for the insects.

*C. maculatus* was exposed to each of these temperatures for 15 minutes, 4 hours or 12 hours. The experiment was repeated with a new group of insects when all the treated ones died. At the end of each experiment the insects were removed, weighed and placed in Petri dishes containing moist filter papers. Records were kept only for temperatures where deaths occurred. Those that did not recover after 12 hours were presumed dead. The number of dead insects was recorded at the end of this period.

Cowpea seeds were exposed to temperatures of 40°C, 60°C, 80°C and 100°C for 0, 4, 8, 12, 16 and 24 hours in batches of 20. The seeds were then planted out in boxes of soil and their germination was recorded.

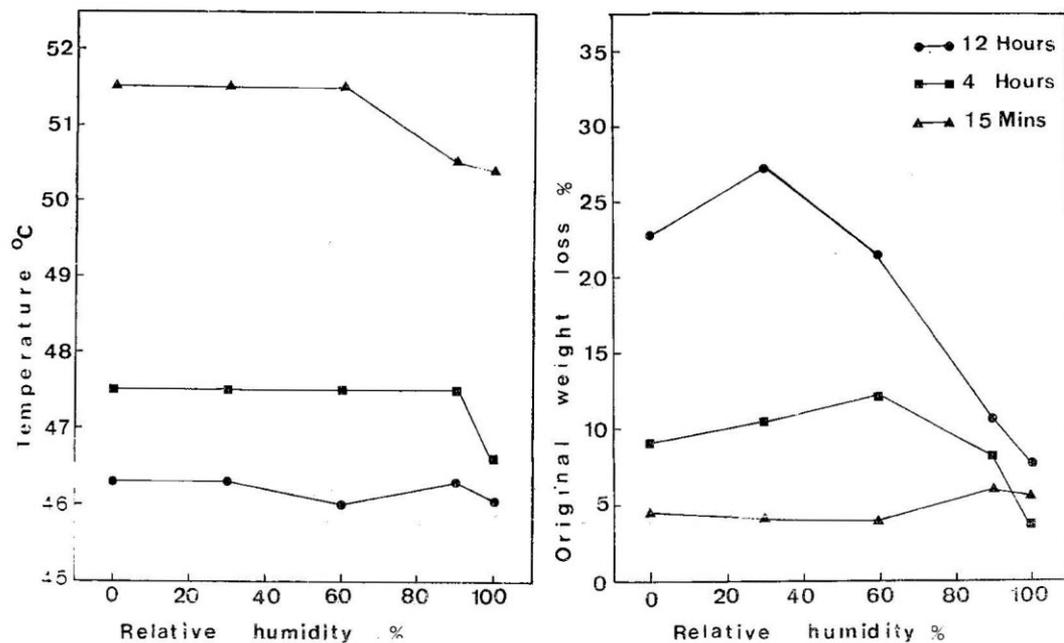


Fig. 1. Relationship between thermal death point and weight loss evaporation in female *C. maculatus* at different relative humidities 15 minutes 4 hours and 12 hours.

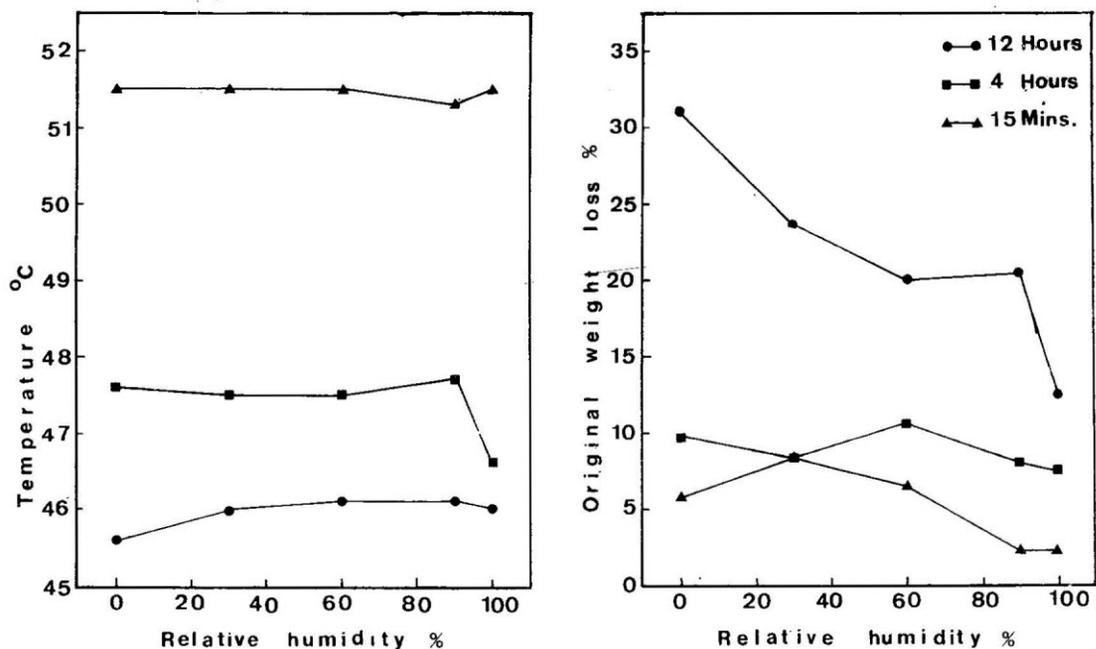


Fig. 2. Relationship between thermal death point and weight Loss by evaporation, in male *C. maculatus* at different relative humidities 15 minutes 4 hours and 12 hours.

## RESULTS

The thermal death points and weight loss by evaporation in female and male *C. maculatus* are given in Figs. 1 and 2 respectively. For 15 minutes exposure the thermal death point for both sexes was 51.5°C at 0% and 60% relative humidity, 50.4°C for females and 51.2°C for males at 90% relative humidity, with a corresponding weight loss of 5% for females and 6% for males. For 4 hours exposure, the thermal death point was 47.5°C for 0%, 30%, 60% and 90% r.h. dropping to 46.5°C at 100% r.h. There was a maximum weight loss of 12.5% for females and 10.5% for males at 6% r.h. On exposure for 12 hours, both males and females survived at 46°C, but could not live above 46.5°C. Weight loss was as high as 31% in males at 0% r.h. and 27.5% in females at 30% relative humidity. Thus both sexes have comparable temperature tolerance thresholds.

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Analysis of variance test showed that in both male and female *C. maculatus*, weight loss was less at higher than at lower humidity levels. Mean weight loss was highest at 50°C in females exposed for 15 minutes while, in the males, weight loss was significantly higher at 52°C, and 49°C than at 51°C and 48°C (Table 1).

**Table 1. Percentage weight loss of *C. maculatus* at different temperatures and relative humidities after 15 minutes exposure.**

(a) *Females:*

Temperature (°C)	Relative humidity (%) / Percent Wt. loss					Mean
	0	30	60	90	100	
52	6.45	6.95	5.95	5.97	5.62	5.40
51	4.68	4.08	4.01	0.02	0.53	3.52
50	7.29	7.72	7.07	6.04	5.48	6.72
49	5.68	5.62	6.98	4.42	5.36	5.63
48	5.35	3.93	3.03	2.99	1.99	3.46

LSD (5%) 1.23 )  
1% 1.69 ) for both R.H. & Temp.

(b) *Males:*

52	9.20	10.46	8.43	1.03	3.62	6.14
51	5.75	8.33	6.43	2.11	2.32	4.99
50	7.29	14.33	5.06	5.33	3.01	7.04
49	8.05	7.11	9.02	4.30	4.51	6.40
48	2.29	5.31	3.38	1.79	0.58	2.44

LSD (5%) R.H. and Temp. = 2.82.

**Table 2. Percentage weight loss of *C. maculatus* at different temperatures and relative humidities after 4 hrs. exposure.**

(a) *Females*

Temperature (°C)	Relative humidity (%) / Percent Wt. loss					Mean
	0	30	60	90	100	
48	14.41	12.42	12.63	7.54	4.40	10.28
47	9.06	10.61	12.33	7.16	3.77	8.58
48	8.20	12.75	19.43	10.24	7.51	11.63

LSD (5%) 4.61 (Temperature); 3.57 (relative humidity).

(b) *Males*

48	15.21	9.85	14.01	4.88	0.95	44.90	8.98
47	9.86	8.45	10.61	5.44	1.57	35.77	7.15
46	11.25	9.26	8.99	7.57	5.07	42.14	8.43

LSD (5%) 3.94 (Relative humidity); 3.48 (Temperature).

LSD (5%) R.H. = 3.94, Temp. = 3.05.

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**Table 3: Percentage weight loss of *C. maculatus* at different temperatures and relative humidities after 12 hours exposure.**

(a) *Females*

Temperature ( <sup>o</sup> C)	Relative humidity (%) / Percent Wt. loss					Mean
	0	30	60	90	100	
47	26.80	30.75	12.12	12.99	3.10	17.15
46	22.91	27.38	21.49	10.62	7.74	18.03
45	15.25	14.43	9.00	4.14	4.34	9.43

LSD (5%) 8.91 (Relative humidity); 6.90 (Temperature).

(b) *Males*

47	26.51	33.22	28.19	16.75	12.46	23.43
46	31.42	23.59	20.11	20.56	12.45	21.63
45	19.74	14.41	10.53	8.29	8.44	12.28

LSD (5%) R. H. = 10.54, Temp. = 8.16

For 4 hours exposure, weight loss did not differ significantly at the various temperatures used for both sexes. Weight losses after both 4 and 12 hours were significantly higher ( $P < 0.05$ ) at lower than at higher humidity levels (Table 2). Weight losses observed for 12 hours exposure were much higher than those observed at 4 hours, for most of the various temperatures and relative humidities tested (Table 3).

Of the cowpea seeds heated at a temperature of 60<sup>o</sup>C for 24 hours 95% were viable. Above this temperature, viability decreased (Table 4).

**Table 4. % germination of cowpea seeds exposed to various temperatures for different periods.**

Degree of heat <sup>o</sup> C	Hours of heating					
	0	4	8	12	16	24
40	19*	19	19	19	18	19
60	19	12	19	16	16	19
80	15	0	0	0	0	0
100	19	0	0	0	0	0

\*Twenty seeds were used in each case.

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### DISCUSSION

This study has shown that *C. maculatus*, could withstand a temperature as high as 51.5°C for 15 minutes. Generally, weight loss in male and female *C. maculatus* was lower at higher humidities for the various periods of exposure, but with prolonged exposure at lower temperatures, *C. maculatus* lost more weight. Thus at 30% relative humidity, female *C. maculatus* lost 12.5% of its body weight at a thermal death point of 47.5°C for 4 hours exposure while a weight loss of 27.5% at a thermal death point of 46.5°C was recorded for 12 hours exposure. Thus for a difference of 1°C, an extra 15% body weight was lost at 30% relative humidity. This showed that in *C. maculatus*, death at 12 hours exposure was due more to a loss of moisture through evaporation than to temperature effects and, therefore, cannot be taken as the true thermal death point. The true death points are those obtained at 15 minutes and 4 hours exposure while death at 12 hours is due to the combined effects of high temperature and desiccation of *C. maculatus* through evaporation.

The determination of the above thermal thresholds for *C. maculatus* has established the temperature at which a store can be maintained to the exclusion of *C. maculatus*, without losing the viability of stored seeds. In this study cowpea seeds heated to 60°C for 24 hours had a germination rate of 95%

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### REFERENCES

- BUXTON, P.A. 1931. The measurement and control of atmospheric humidity in relation to entomological problems. *Bull. ent. Res.* 22: 431 - 441.
- CASWELL, G. H. 1970 The storage of cowpea in the Northern States of Nigeria. *Proceedings of the Agricultural Society of Nigeria* 5: 1968; *Samaru Research Bulletin* 120: 4-6.
- HOWE, R.W. and J.C. CURRIE 1964 Some laboratory observations on the rates of development, mortality and oviposition of several species of Bruchidae breeding in stored pulses. *Bull. ent. Res.* 55: 437 - 477.
- MADGE, D.S. The control of relative humidity with aqueous solution of sodium hydroxide. *Entomologia Exp. Appl.* 4: 143 - 147.
- MADGE, D.S. The effects of lethal temperature on oribatid mites. *acarologia* 7: 121-129
- SOLOMON, M.E. 1945 The use of cobalt salt as an indicator of humidity and moisture. *Annals. appl. Biol.* 32: 75 - 85.
- TAYLOR, T.A. 1974 Observations on the effect of initial population densities in culture and humidity on the production of "active" females of *Callosobruchus maculatus* F. J. *Stored Prod. Res.* 10: 113 - 122.