Intraspecific Kernel-entry Behavior and Competition Among Larvae of the Angoumois Grain Moth

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Intraspecific Kernel-entry Behavior and Competition Among Larvae of the Angoumois Grain Moth[1]

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Abstract

The internecine activities of internal-feeding Angoumois grain moth larvae, *Sitotroga cerealella* (Oliv.), were studied by placing newly-hatched larvae with kernels (with or without pre-drilled holes) already infested, by placing 1, 2, or 4 larvae with each kernel (with or without holes), and by introducing 2 larvae/kernel in holes pre-drilled at different locations on the kernel. A larva placed with an infested kernel usually entered by the hole previously used. The second larva was usually killed or driven from the kernel by its original inhabitant. Two larvae introduced into pre-drilled holes in a wheat kernel intercepted each other faster when the holes were on opposite sides of the germ than when one hole was in the germ and one in the mid-kernel, and still slower when one hole was in mid-kernel and the other at the brush end. Two larvae could develop to maturity concurrently in one kernel with an aluminum foil barrier cemented between its halves.

The Angoumois grain moth (*Sitotroga cerealella* (Oliv.), Family Gelechiidae) is a buff moth 13 mm long that usually oviposits among grain kernels. The eggs hatch in a few days and the newly-hatched larvae bore into kernels, or enter through cracks, and develop to adults inside the kernels.

Duhamel and Tillet (1762) noted internecine activities among newly-hatched Angoumois grain moth larvae. They reported that M. de Reamur also had observed that phenomenon at least 20 years earlier. Others, including Crombie (1944 and 1946), reported competition of larvae for kernel-entry sites and also defensive behavior shown by established larvae as their tunnels were opened during dissections of infested kernels. This study obtained further details of intraspecific competition.

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Materials and Methods

Angoumois grain moths were reared at 80°F (± 2°) and 65% (± 3%) relative humidity on Ponca hard red winter wheat (1963 crop) with approximately 12.3% moisture. Moisture content was determined with a Steinlite Electronic Moisture Tester, Type G, calibrated by the air-oven method. Eggs were collected after being oviposited on black paper strips (Mills 1965) and placed, attached to pieces of the black paper, in a vial to incubate. Upon hatching, each larva was removed with a small camel's-hair brush and transferred to a #00 gelatin capsule containing one wheat kernel.

Preliminary studies showed that newly-hatched larvae readily enter kernels through pre-drilled holes made with a 0.34 mm bit. Crombie (1944) noted that larvae entered more easily after cracks had been made in bran coats. Holes greatly increased the percentage of larvae entering and, given a choice of holes in different areas over the wheat kernel, larvae showed preference for holes near the germ. Pre-drilled holes guided larvae into desired locations inside (Fig. 1).

Competition Tests

Second larvae (b-larvae) were added singly to kernels with or without holes already containing larvae (a-larvae) of varying ages (2, 8, 13, 19, and 25 days). The hole in each drilled kernel was in the edge of the germ (Fig. 1a). Kernels were dissected with a razor blade under a binocular microscope on the third day after b-larvae were added. Table 1 shows little difference in larval survival in kernels with or without holes. Single larvae were found in 39 of the 50 kernels without holes and in 43 of 50 kernels with pre-drilled holes. The established a-larvae, 8, 13, 19, and 25 days old, killed or repelled b-larvae entering kernels. The dead always were smaller b-larvae. When identities could be determined, it was the established 2-day-old a-larvae that survived attacks of newly-hatched b-larvae. If 2 larvae were found alive in the same kernel, one usually was an a-larva 19 or more days old when the b-larvae was added. Such b-larvae survived because the a-larvae had become pupae or had tunneled away from the entry holes so the two made no contact. Apparently the b-larvae, while outside of the kernels, were unaware of a-larvae inside because b-larvae readily entered the same holes.

Number of different larvae entering single kernels (20 per group) with or without holes drilled in the germ end was observed (Fig. 1a). When 2 or 4 larvae were placed with each kernel without holes, one larva survived after 3 days in only 30% of the kernels in each group (Table 2). Two larvae survived in only one of the kernels. When kernels with one

hole in the germ each was infested with 1, 2 or 4 newly-hatched larvae, one live larva was found after 3 days in each of 85, 95, and 50% of the kernels, respectively. Two live larvae were found in only one of the kernels originally infested with 2 larvae. Three kernels infested with 4 larvae each contained 2 live larvae. Both larvae were alive after 3 days in 60% of the kernels with 2 holes near the germ (Fig. 1b) and originally infested with 2 larvae. In sound kernels without holes, survival was low. Adding more larvae per kernel only slightly increased the percentage of kernels with survivors.

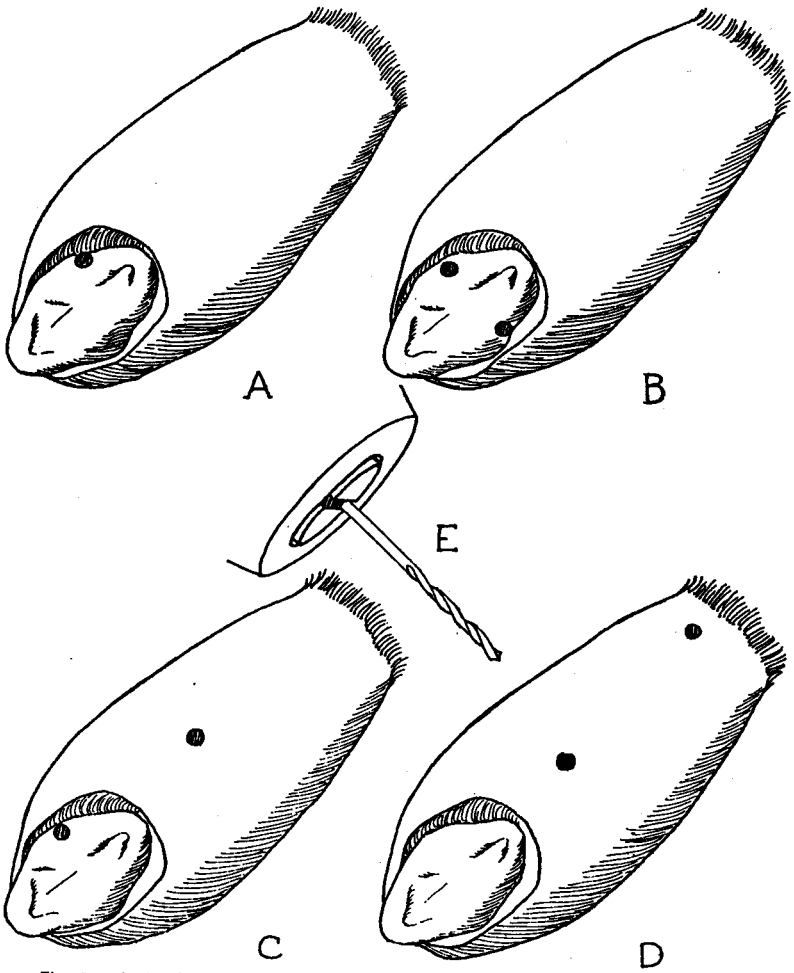

Fig. 1. A, B, C, D. Locations of holes drilled in wheat kernels prior to infestation with Angoumois grain moth larvae. E. Bit used to drill holes (diameter 0.34 mm).

Crombie (1944) reported that two larvae would meet in the same kernel only randomly and then at least one would be killed or migrate. We also studied tunneling behavior of 2 larvae in one kernel. Sixty kernels each with 2 drilled holes were infested with 2 larvae each and X-ray radiographs were taken every 24 hours. Table 3 shows days

Table 1. Entry and survival of newly-hatched Angoumois grain moth larvae (b-larvae) individually placed with single wheat kernels (with or without pre-drilled holes) containing larvae (a-larvae) of various ages (10 kernels in each group).

Age of original larvae when b-larvae were added	Live larvae after 3 days in kernels without holes				Live larvae after 3 days in kernels with holes			
	One/kernel		Two/kernel		One/kernel		Two/kernel	
	No.	%	No.	%	No.	%	No.	%
2	7	70	0	0	10	100	0	0
8	9	90	0	0	7	70	1	10
13	6	60	0	0	9	90	0	0
19	8	80	2	20	9	90	0	0
25	9	90	1	10	8	80	1	10

Table 2. Success of entry of newly-hatched Angoumois grain moth larvae into wheat kernels with or without pre-drilled holes in germ end (20 kernels per test).

No. of holes	Larvae added per kernel	Kernels with one live larva after 3 days		Kernels with 2 live larvae after 3 days	
		No.	%	No.	%
0	2	6*	30	0	0
0	4	6	30	1	5
1	1	17	85	--	--
1	2	19	95	1	5
1	4	10	50	3	15
2	2	7*	35	12	60

* Average of 2 replicates.

Table 3. Effect of entry site on time required for 2 Angoumois grain moth larvae to meet in the same wheat kernel. A second larva was placed with each kernel 2 days after the original larva entered (20 kernels/test).

Location of pre-drilled holes	Kernels with 2 larvae meeting*	Days required for interception after second infestation	
		Range	Average
Two in germ	13	8–15	12.5
One in germ, One in mid-kernel	7	7–31	16.5
One in mid-kernel, One in brush end	9	11–31	22.5

* In each remaining kernel one larva did not enter, or did not survive until intercepted.

required for contact between the larvae after they entered holes drilled at different locations in the same kernel. The holes were as follows: two in germ for one set of kernels, one in germ and one in mid-kernel for another set, and a hole in mid-kernel and one in the brush end of each kernel in the third set (Figs. 1b, 1c, 1d).

When both larvae entered the germ, they developed rapidly. Being close together, they met rather quickly (average 12.5 days). With one hole in the germ and one in mid-kernel, larvae met after an average of 16.5 days. An example where two such larvae met 29 days after they first entered is shown in Fig. 2. According to X-ray radiographs and

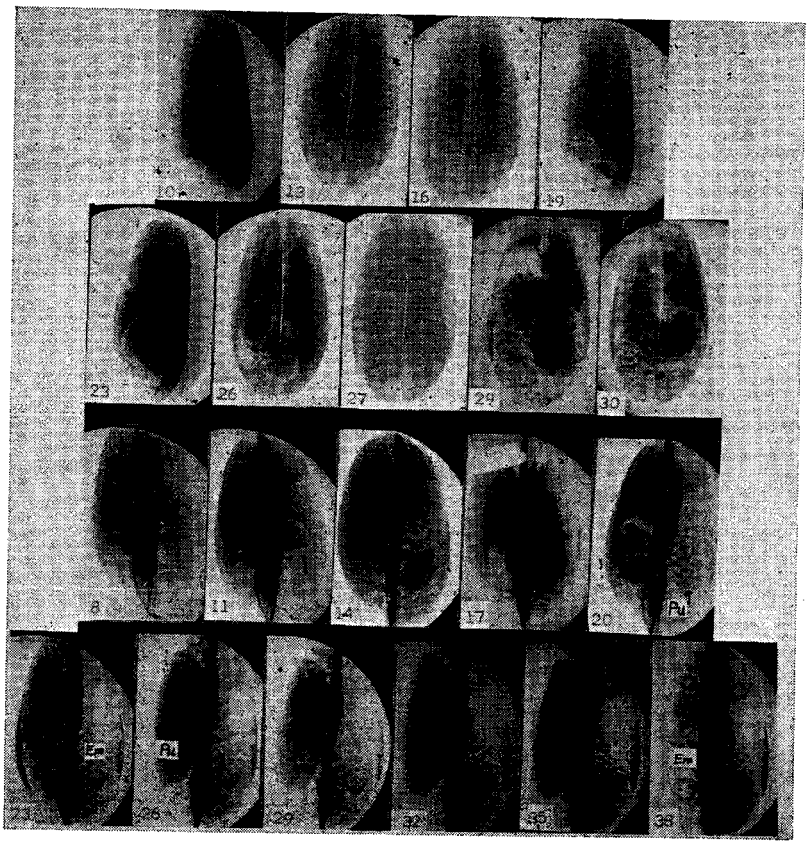

Fig. 2. Life cycles of 2 Angoumois grain moth larvae inside one wheat kernel (upper 2 rows) and in kernel halved by aluminum foil (lower 2 rows). Numbers in first set refer to age in days of larvae in germ portions of kernels (upper larvae 2 days younger). In the second set, numbers correspond to age of larvae on left sides of kernels (one on right 7 days older). Pu denotes pupa stage; Em, emergence of moth in kernel with aluminum foil. Nos. 10, 19, and 23 in upper two rows show kernels rotated approximately 90 degrees.)

dissections, the one that entered the endosperm was killed; the one that entered the germ survived. When one hole was drilled at the brush end and one at mid-kernel, larvae met after 22.5 days (average). The results show more rapid development of larvae that feed early on the germ

In preceding tests, the 2 moth larvae contacted each other and, in most cases, one was killed (Fig. 2). A test was designed to determine whether or not two insects could develop concurrently in the same kernel if separated by a barrier. Three replicate tests of 22 kernels each were conducted. Each kernel was cut in half longitudinally at the crease and the two halves cemented back together with a aluminum foil between them using Elmer's Glue-All. Each half-kernel had a small hole drilled through the bran covering to expose part of the germ. An individual newly-hatched larva was put with each single wheat kernel in a gelatin capsule. Seven days later its entry hole was sealed with glue and another larva was added. From 4 days after the entry of the second larva X-ray radiographs were taken at 3-day intervals to record larval development (Fig. 2).

Percentage emergence of 2 moths from the same kernel ranged from 40.9% to 68.1% (Table 4), indicating that 2 insects could develop concurrently in the same wheat kernel if separated. At least one moth emerged in all but 2 kernels.

Table 4. Concurrent development of 2 Angoumois grain moth larvae separated by aluminum foil in a wheat kernel (22 kernels per test).

Kernels with 2 moths emerging		Kernels with only one moth emerging		Kernels with no moth emerging	
No.	%	No.	%	No.	%
15	68.1	7	31.8	0	0
12	54.5	9	40.9	1	4.5
9	40.9	12	54.5	1	4.5
12 Av.	54.5	9.1	42.6		

These studies indicated that larvae readily entered holes made by other larvae or with a small drill bit. A larva established inside a kernel had a definite advantage over a second entering larva, usually killing it or driving it from the kernel. Two larvae in the same kernel met faster if one or both fed on germ early in development. Two larvae usually developed to maturity concurrently in the same wheat kernel only when separated by a barrier.

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