DISCUSSION

The calling and mating behavior of *Nephopterix* moths appears to be similar to the behavior of other moth species[7,8,9,10,11]. In many moth families, the sex pheromone gland is located in the terminal abdominal segments[3,7,12,13,14]. The calling behavior consists of exposing the gland by extruding it into the airstream[7,15] along with related postural changes, i.e. wings extended away from the body and the abdomen eleveated into the air. The extrusion of the terminal segments of abdomen is an accepted criterior for pheromone release[16,17,18]. However it is possible that the extrusion of the apical abdominal segments does not always result in pheromone release[14].

In several moth species, a male exhibits mating dance when a calling female is located[7,8,10,11]. The

Table 2. The effects of age on onset of mating and time spent mating by *Nephopterix* moths. Summary of ANOVA. Variances were homogenous (Cochran's C = 0.20 and 0.23, P > 0.05).

		Onset of mating		Time spent mating	
Source of variance	df	MS	P	MS	P
Age	6	1.99	-	1343	-
Linear trend	1	5.30	0.00	5752	0.00
Quadratic trend	1	4.41	0.00	923	0.18
Cubic trend	1	0.12	0.48	24	0.83
Error	95	0.25		512	

Fig.3. Distribution of mating times for the first seven scotophase after eclosion in *Nephopterix* females. The line over the top histogram represents the duration of the scotophase. For ages 1 to 7, N = 51, 49, 43, 45, 46, 50, 47.

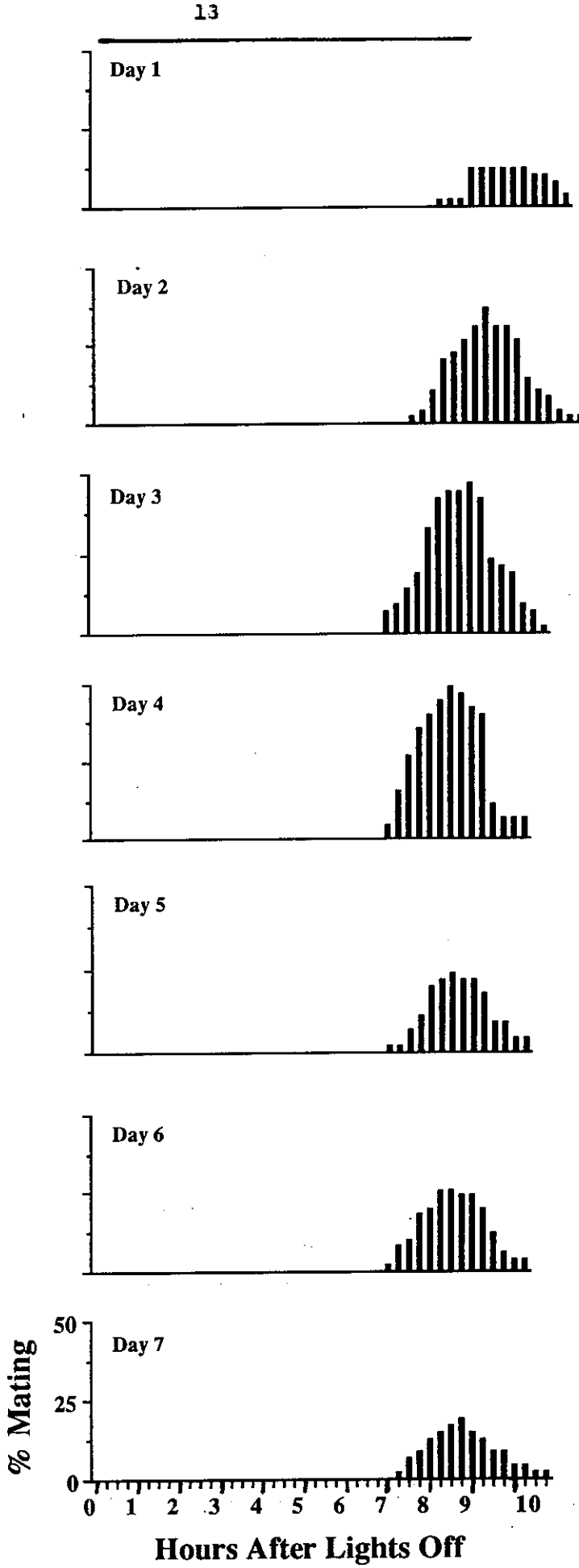
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
% Mating
50
25
0
0 1 2 3 4 5 6 7 8 9 10
Hours After Lights Off

Fig. 3

Fig.4. Effects of age on (A) onset of mating and (B) time spent mating for *Nephopterix* moths. Vertical bars represent ± SE. For ages 1 to 7, N=6, 18, 21, 22, 11, 15, 9.

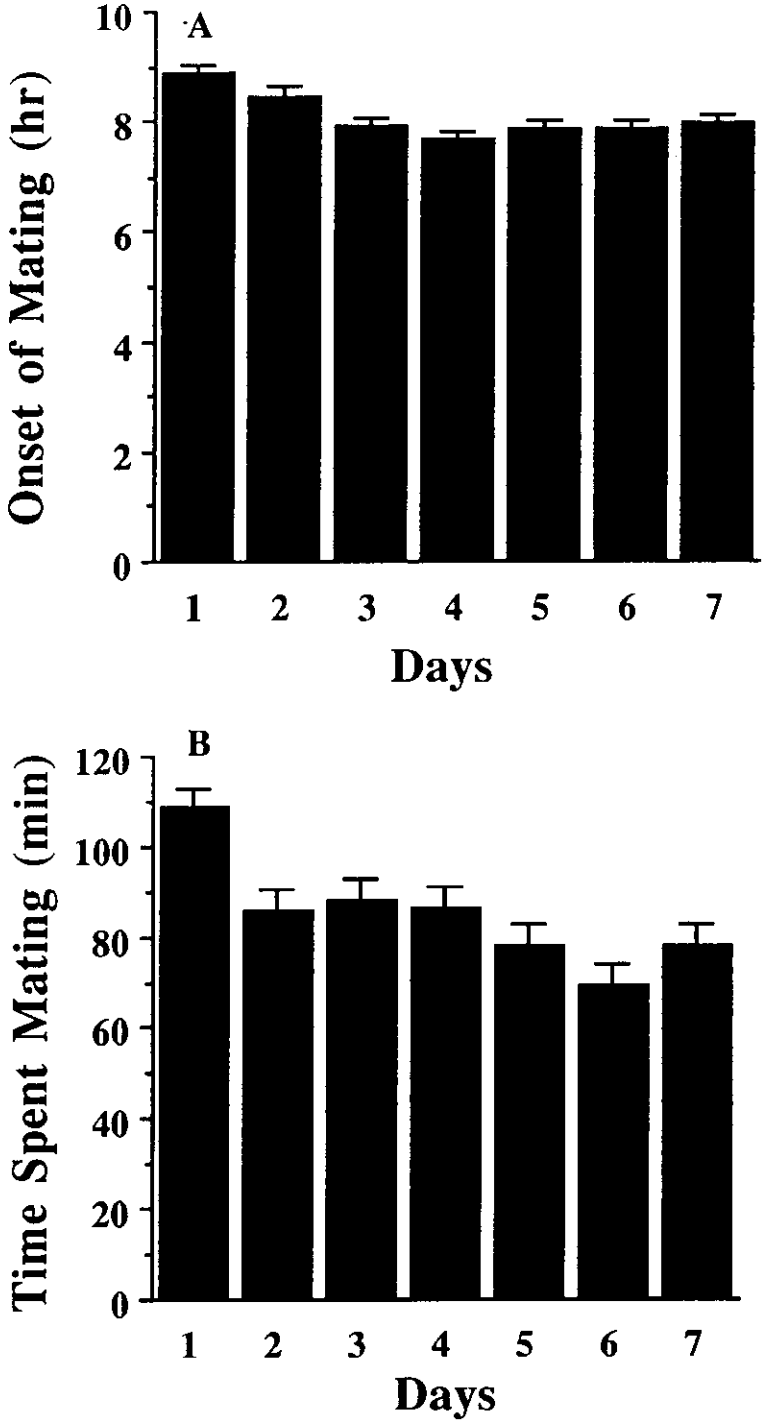
A
Onset of Mating (hr)
10
8
6
4
2
0
1
2
3
4
5
6
7
Days
B
Time Spent Mating (min)
120
100
80
60
40
20
0
1
2
3
4
5
6
7
Days

Fig. 4

mating dance is characterized by wing fluttering, antennal waving and exposing hair pencils. While probing along the female body, the male bent his abdomen toward the female to initiate genital contact. However Seol et al[9] was unable to observed the mating dance in the lesser mulberry pyralid, *Glyphodes pyloalis* Walker, since the male copulated almost immediately after landing near a calling female.

Both calling and mating activities of *Nephopterix* moths occur very late, ca 7-8 hr after the onset of the 9-hr scotophase, suggesting that in the field female *Nephopterix* probably call and mate at dawn. The present results show clearly that patterns of calling and mating varied with age. The percentages of individuals calling and mating was low on day 1, but increased rapidly on the next days, with a trend toward earlier onsets of calling and mating. Older females tended to spend more time on calling. However older moths spent less time on mating.

Effects of age on calling and mating have been studied in many moth species. In *G. pyloalis*, the frequency of calling was high in females up to 4 or 5 days old and thereafter decreased with age. By contrast the mating activity was low on day 1 and then increased with age[9]. A similar trend was observed in the rice stem borer, *Chilo suppressalis* (Wlk)[19] and the potato stem borer, *Hidraecia micacea* Esper[20]. Swier et al[21] established that ovarian development was highly correlated with calling behavior in the black cutworm, *Agrotis ipsilon* (Hufnagel), and that the percentage of 1-day-old black cutworm moths calling was lower than that of older moth[22]. In *Nephopterix*, the low percentages of 1-day-old individuals calling and mating suggests that females are not reproductively mature upon emergence.

Previous studies showed that the onsets of calling and mating shifted earlier with age[14,19,22]. Swier et al[22]

noted that the time of starting calling in *A. ipsilon* was correlated with increased reproductive maturity, and it seems that by calling earlier, older females increase their chances of mating by being the first to attract males. The advance in the onset of calling and mating in response to age was also reported in the tobacco hornworm, *Manduca sexta* (L_1) by Itagaki and Conner[14]. They also mentioned that mating times could not be equated calling times because calling preceeded mating, and mating resulted in the cessation of calling.

The present results show that the mean onset of mating are slightly earlier than that of calling especially in 3-day-old moths and the older. This implies that some female *Nephopterix* probably secret pheromone without assuming a typical calling posture. However some species do not display this age correlate change in calling and mating initiation[9,20].

Most female moths lengthen their calling time when they get older[9,19]. The prolonged calling in older moths was also reported in *H. micacea*, suggesting that by extending calling duration, older females increase their probability of competing for males[20]. In the case of *Nephopterix*, older females probably enhance their chances of mating by both calling earlier and broadening the calling time.

CONCLUSION

Female *Nephopterix* exhibit a calling behavior just before mating during which the sex pheromone is presumably released. The production and release of pheromone in *Nephopterix* is under investigation. It seems that the sex pheromone should be extracted from 2-to 5-day

old virgin females because they are most likely to call. According to their high mating activity, the bioassay of the pheromone extract should be performed using 2-to 5-day-old males. It appears that the optimal time for the extraction and bioassay is ca.7-8 hr after the onset of the 9-hr scotophase during the hours when they observed maximum sexual behavior.

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