However, the degree of sterility was variable with each chemosterilant and the concentration tested. Oviposition was totally inhibited in flies emerged from pupae of various ages dipped in 4.0 percent solution of tepa. Complete sterility was also observed with apholate and metepa at concentration of 4.0 percent of the chemicals while hempa and hemel could not produce high degree of sterility at any concentration and period suggesting that aziridine compounds hold superiority over non alkylating agents in pupal treatments.

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Permanency of Sterility Effects of Chemosterilants in *Musca domestica nebulo* Fabr.

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19. 不妊剤施用イエバエ *Musca domestica nebulo* Fabr. における不妊効力の持続性

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Apholate, tepa, metepa, hempa および hemel をイエバエ *Musca domestica nebulo* の雌雄に施用し，それぞれの不妊効力の持続性を調べた．雄にこれらの不妊剤を施用して，つぎつぎと正常な雌4匹と交尾させ，産卵数，ふ化率を調べた結果，いずれもふ化幼虫数が極めて少なく，不妊効力が持続することがわかった．一方，雌に施用した場合，施用不妊剤の濃度が高いと，その雌から産れた卵のふ化率は最初から終りまで低く，不妊効力の持続を示したが，施用量が少ないと，後から産れる卵のふ化率が高くなり，不妊効力が持続しないことがわかった．

The choice of a chemosterilant would greatly depend on its low toxicity and the permanence of sterility. Knipling (1964) has stressed the necessity for the permanence of sterility in practical application of sterile male release technique but the results obtained by other workers show that this effect is variable from species to species and the chemosterilant used. Morgan and Labrecque (1962, 1964) observed a degeneration in oocytes in the ovarian chambers of chemosterilized houseflies and Weidhaas *et al.* (1961) obtained a much higher sterility in *Aedes aegypti* when the females were fed on a diet treated with alkylating compounds. Dame and Ford (1964) conducted experiments to determine the permanency of sterility effects produced by apholate and tepa in *Aedes aegypti* and reported that males treated with apholate recovered after four series of mating but those treated with tepa retained a high degree of sterility during successive matings.

Kilgore and Painter (1962) reported that recovery of fertility occured when the flies were fed on a diet containing 5-fluorouracil for 36 to 48 hours after emergence. Similar results were obtained by Sacca *et al.* (1964) with tepa in case of *M. d. domestica*. Painter and Kilgore (1964) tested fifteen comounds against *M. d. domestica* and found that only apholate and thiotepa induced permanent sterility and none of the eggs deposited were viable. Lachance *et al.* (1969) reported that the minimum dose of apholate, tepa, metepa and hempa which produced dominant lethal mutation in the sperms also caused 100.0 percent mortality of the gonial cells and no sign of any spermatogenetic activity could be observed in

tests even after fourteen days. Riemann and Thorsin (1969) observed dominant mutation in over 90 percent of the mature sperms subjected to 3000-2500 radiation dose. It seems that the production of sperms could have been inhibited through the destruction of primary spermatogonia.

The above findings prompted the author to find out the effects of apholate, tepa, metepa, hempa and hemel on the nature of sterility effects in males and females of *M. d. nebulo* and to find out if such effects were permanent.

Materials and Methods

On emergence the males were fed on sugar treated with 0.03125, 0.0625, 1.0 or 2.0 percent of apholate, tepa, metepa, hempa or hemel for four days, while the females were given untreated sugar for the same period. On fifth day the treated males were allowed to mate with an equal number of virgin females of the same age in a cage 8×8″ in size constructed of wire frame and covered over by mosquito netting. After 48 hours, when the males were supposed to have mated at least once, they were transferred to another cage containing the same number of virgin untreated females of the same age for a second time. In this way each male was given an opportunity to mate with four females at intervals of 48 hours in such a way that the age of the females remained the same as that of the males. Similar tests were made using untreated males and females. Random samples of 100 eggs were collected for fifteen days and placed on black moist cloth to determine the rate of hatching.

The permanency of such effects in females was studied by placing females that had earlier been treated with a desired concentration of a chemosterilant in a small cage 3×3″ in size and allowing them to mate with normal males of the same age. In this way single pair matings were established. Fifteen pairs of each type were studied for fecundity and fertility. The number of eggs in each batch was counted and the percent hatching of eggs in each of the four batches laid by a female was determined.

Results

It is clear from tables 1-5 that sterility induced by apholate, tepa, metepa, hempa and hemel in males remain more or less constant and no significant loss is obtained during successive matings. Net sterility of 98.2 percent was obtained from apholate treated males in their first mating with normal females as against 97.6 percent net sterility observed in the fourth mating. This is in contrast to the findings of Sacca *et al.* (1964) who reported that the flies sterilized by tepa may recover fertility after fourteen days of the treatments but support Lachance *et al.* (1969) who reported that males treated with tepa showed no recovery of spermatogenic activity. Similarly the males treated with metepa were able to produce equal or even slightly higher degree of sterility in their fourth mating; 97.4 as against 96.4 observed in the first mating. Hempa and hemel were also more or less equally potent in inducing permanent sterility in males during successive matings.

Table 1. Permanency of sterility effects of apholate in the males.

Mating series	Type	No. of eggs observed	No. of hatched eggs	Percent hatch	Percent sterility	Percent net sterility
I	♂T×♀N	1400	20	1.4	98.6	98.2
	♂N×♀N	1400	1117	79.7	20.3	—
II	♂T×♀N	1300	32	2.4	97.6	96.9
	♂N×♀N	1400	1098	78.4	21.6	1.6
III	♂T×♀N	1500	35	2.3	97.7	97.02
	♂N×♀N	1300	1007	77.4	22.6	2.8
IV	♂T×♀N	1400	27	1.9	98.1	97.6
	♂N×♀N	1300	1015	78.07	21.9	2.07

0.0625% Apholate was given in the diet of newly emerged males for four days.

Table 2. Permanency of sterility effects of tepa in the males.

Mating series	Type	No. of eggs observed	No. of hatched eggs	Percent hatch	Percent sterility	Percent net sterility
I	♂T×♀N	900	0	0.0	100.0	100.0
	♂N×♀N	1400	1117	79.7	20.3	—
II	♂T×♀N	800	0	0.0	100.0	100.0
	♂N×♀N	1400	1098	78.4	21.6	1.6
III	♂T×♀N	900	0	0.0	100.0	100.0
	♂N×♀N	1300	1007	77.4	22.6	2.8
IV	♂T×♀N	1100	0	0.0	100.0	100.0
	♂N×♀N	1300	1015	78.07	21.9	2.07

0.03125% Tepa was given in the diet of newly emerged males for four days.

Table 3. Permanency of sterility effects of metepa in males.

Mating series	Type	No. of eggs observed	No. of hatched eggs	Percent hatch	Percent sterility	Percent net sterility
I	♂T×♀N	1400	40	2.8	97.2	96.4
	♂N×♀N	1400	1117	79.8	20.3	—
II	♂T×♀N	1500	31	1.06	98.9	98.4
	♂N×♀N	1400	1098	78.4	21.6	1.6
III	♂T×♀N	1400	44	3.1	96.9	95.9
	♂N×♀N	1300	1007	77.4	22.6	2.8
IV	♂T×♀N	1400	43	2.07	97.9	97.4
	♂N×♀N	1300	1015	78.07	21.9	2.07

0.0625% Metepa was given in the diet of newly emerged males for four days.

Table 4. Permanency of sterility effects of hempa in the males.

Mating series	Type	No. of eggs observed	No. of hatched eggs	Percent hatch	Percent sterility	Percent net sterility
I	♂T×♀N	1500	0	0.0	100.0	100.0
	♂N×♀N	1400	1117	79.7	20.3	—
II	♂T×♀N	1400	0	0.0	100.0	100.0
	♂N×♀N	1400	1098	78.4	21.6	1.6
III	♂T×♀N	1400	0	0.0	100.0	100.0
	♂N×♀N	1300	1007	77.4	22.6	2.8
IV	♂T×♀N	1300	9	0.4	99.4	99.3
	♂N×♀N	1300	1015	78.07	21.9	2.07

1.0% Hempa was given in the diet of newly emerged males for four days.

The permanent sterility caused by these compounds in males may be the result of total destruction of spermatogonia. It has already been reported by Lachance *et al.* (1969) that aziridine compounds and non alkylating agents like hempa induce sterility in males of *M. d. domestica* by killing all the gonial cells and leaving no sign of spermatogenic activity in testes even after fourteen days of treatments.

The permanency of such effects was also studied in females and the results obtained (Tables 6-10) show that sterility induced in females is somewhat erratic and does not follow any specific pattern. However, no recovery of

Table 5. Permanency of sterility effects of hemel in the males.

Mating series	Type	No. of eggs observed	No. of hatched eggs	Percent hatch	Percent sterility	Percent net sterility
I	♂T×♀N	1500	0	0.0	100.0	100.0
	♂N×♀N	1400	1117	79.7	20.3	—
II	♂T×♀N	1400	0	0.0	100.0	100.0
	♂N×♀N	1400	1098	78.4	21.6	1.6
III	♂T×♀N	1300	6	0.4	99.6	99.4
	♂N×♀N	1300	1007	77.4	22.6	2.8
IV	♂T×♀N	1300	18	1.3	98.7	98.3
	♂N×♀N	1300	1015	78.07	21.9	2.07

2.0% Hemel was given in the diet of newly emerged males for four days.

fertility could be observed when oviposition was totally retarded. The females lost their sterility in successive egg layings depending upon the concentration tested. At higher concentrations sterility was more or less permanent when treated with apholate, tepa, metepa and hempa but females treated with hemel lost their sterility in successive egg layings even at a concentration of 3.0 percent.

The loss of sterility appears to be somewhat proportional to the initial sterility in the females. In other words the higher the initial sterility, the lesser is the loss. Apholate (0.0625 percent) caused an initial sterility of 76.3 percent in the females. This was decreased to 69.5 percent after the third batch of eggs. At 0.0156 percent concentration of apholate the loss was much higher and the initial sterility decreased to 52.7 to 24.6 percent after the third batch of eggs was laid. Similarly the females treated with metepa, hempa and hemel lost their sterility after each egg laying and recovered earlier than the females treated with apholate. In contrast to this, tepa induced most consistent sterility in females and no recovery was observed at any of the concentration tested. The above observations

Table 6. Permanency effects of apholate in the females.

Concentration	Serial no. of egg batches	Eggs per batch	No. of hatched eggs per batch (%)	Percent hatch	Percent sterility	Percent net sterility
0.125	—	**	—	—	—	—
0.0625	I egging	63.6	0.83	1.3	98.7	98.4
	II egging	43.2	1.7	4.04	95.9	94.3
	III egging	19.2	0.2	1.2	98.8	98.4
	IV egging	16.0	0.0	0.0	100.0	100.0
0.03125	I egging	56.9	11.4	20.03	79.9	76.3
	II egging	58.5	14.1	24.3	75.7	66.8
	III egging	42.7	9.1	21.5	78.5	72.2
	IV egging	34.8	8.6	24.7	75.3	69.5
0.0156	I egging	56.2	22.5	40.02	59.9	52.7
	II egging	55.8	26.0	46.5	53.5	36.4
	III egging	54.9	30.5	55.6	44.4	28.2
	IV egging	51.5	31.5	61.1	38.9	24.6

No. of eggs per batch in normal crosses in I, II, III and IV egging was 80.4, 75.7, 71.07 and 70.4 and percent sterility in the I, II, III and IV egging obtained from normal crosses was 15.2, 26.8, 22.4 and 18.9.

** The females did not oviposit.

Table 7. Permanency of sterility effects of tepa in the females.

Concentration	Serial no. of egg batches	Eggs per batch	No. of hatched eggs per batch (%)	Percent hatch	Percent sterility	Percent net sterility
0.0625	—	**	—	—	—	—
0.03125	I egging	48.5	0.0	0.0	100.0	100.0
	II egging	25.0	0.0	0.0	100.0	100.0
	III egging	41.0	0.0	0.0	100.0	100.0
	IV egging	21.5	0.0	0.0	100.0	100.0
0.0156	I egging	54.7	9.7	15.5	84.5	80.5
	II egging	66.0	9.0	13.6	86.4	81.4
	III egging	46.0	3.5	7.6	92.4	90.2
	IV egging	—	—	—	—	—
0.0078	I egging	42.7	8.3	19.6	80.4	76.8
	II egging	37.7	8.7	23.6	76.4	68.5
	III egging	32.6	8.3	25.5	74.5	67.01
	IV egging	33.0	6.0	18.1	81.9	77.7

No. of eggs per batch in normal crosses in I, II, III and IV egging was 80.4, 75.7, 71.07 and 70.4 and percent sterility in the I, II, III and IV egging obtained from normal crosses was 15.2, 26.8, 22.4 and 18.9.

** The females did not oviposit.

Table 8. Permanency effects of metepa in the females.

Concentration	Serial no. of egg batches	Eggs per batch	No. of hatched eggs per batch (%)	Percent hatch	Percent sterility	Percent net sterility
0.25	—	**	—	—	—	—
0.125	I egging	45.5	4.2	9.2	90.8	87.9
	II egging	48.5	9.2	19.07	80.93	73.9
	III egging	14.7	3.2	22.03	77.97	71.5
	IV egging	12.6	1.3	13.4	86.6	83.4
0.0625	I egging	46.5	19.1	41.2	58.8	51.4
	II egging	48.2	28.4	58.9	41.1	16.8
	III egging	29.0	16.6	57.4	42.6	27.3
	IV egging	24.6	11.3	54.1	45.9	33.2
0.03125	I egging	55.8	31.1	59.4	40.6	29.9
	II egging	47.7	31.3	65.7	39.3	17.07
	III egging	48.6	35.5	73.08	26.9	5.7
	IV egging	38.0	28.0	73.6	26.4	9.2

No. of eggs per batch in normal crosses in I, II, III and IV egging was 80.4, 75.7, 71.07 and 70.4 and percent sterility in the I, II, III and IV egging obtained from normal crosses was 15.2, 26.8, 22.4 and 18.9.

** The females did not oviposit.

are partially in agreement with the findings of Labrecque (1961) who found that aphoxide (tepa), aphomide and apholate induced irreversible sterility in *M. d. domestica* when fed on treated sugar for five days.

The females sterilized with apholate, tepa, metepa, hempa and hemel deposit more non viable eggs in the beginning. This may be due to the fact that the amount of the chemosterilant picked up by the females may have greater effect on the ova maturing first.

Table 9. Permanency of sterility effects of hempa in the females.

Concentration	Serial no. of egg batches	Eggs per batch	No. of hatched eggs per batch (%)	Percent hatch	Percent sterility	Percent net sterility
2.0	—	**	—	—	—	—
1.0	I egging	29.0	0.0	0.0	100.0	100.0
	II egging	25.1	0.0	0.0	100.0	100.0
	III egging	18.6	0.0	0.0	100.0	100.0
	IV egging	14.3	0.0	0.0	100.0	100.0
0.5	I egging	62.4	5.3	8.02	91.9	90.4
	II egging	43.0	8.9	20.7	79.3	71.7
	III egging	54.5	18.5	33.9	66.1	56.3
	IV egging	32.7	15.7	48.09	51.9	40.6
0.25	I egging	57.6	13.5	23.5	76.5	72.2
	II egging	54.1	18.7	34.6	65.4	52.7
	III egging	54.8	18.6	33.9	66.1	56.3
	IV egging	45.2	30.5	66.6	33.4	17.8

No. of eggs per batch in normal crosses in I, II, III and IV egging was 80.4, 75.7, 71.07 and 70.4 and percent sterility in the I, II, III and IV egging obtained from normal crosses was 15.2, 26.8, 22.4 and 18.9.

** The females did not oviposit.

Table 10. Permanency of sterility effects of hemel in the females.

Concentration	Serial no. of egg batches	Eggs per batch	No. of hatched eggs per batch (%)	Percent hatch	Percent sterility	Percent net sterility
4.0	—	**	—	—	—	—
3.0	I egging	63.2	17.7	28.06	71.9	66.8
	II egging	67.8	35.4	52.2	47.8	28.7
	III egging	55.8	33.1	59.4	40.6	23.5
	IV egging	54.5	39.3	72.1	27.9	1.1
2.0	I egging	54.6	20.3	37.1	62.9	56.2
	II egging	56.5	38.1	67.4	32.6	7.9
	III egging	48.6	33.6	69.1	30.9	10.9
	IV egging	41.6	30.5	73.4	26.6	9.4
1.0	I egging	62.9	43.6	69.4	30.6	18.1
	II egging	49.1	32.5	66.1	33.9	9.6
	III egging	59.6	46.0	77.1	22.9	0.6
	IV egging	49.9	35.6	71.4	28.7	10.8

No. of eggs per batch in normal crosses in I, II, III and IV egging was 80.4, 75.7, 71.07 and 70.4 and percent sterility in the I, II, III and IV egging obtained from normal crosses was 15.2, 26.8, 22.4 and 18.9.

** The females did not oviposit.

Summary

Studies were made to study the permanency of sterility effects of apholate, tepa, metepa, hempa and hemel in males and females of *Musca domestica nebulo*. It was found that the initial sterility in males remained more or less permanent and no significant loss could be obtained in successive matings with untreated virgin females when they were treated with

these chemicals. However, the females lost their sterility in successive egg layings except at higher concentrations where oviposition was totally retarded. The loss of sterility depended upon the degree of initial sterility in the females so that the higher the initial sterility the lesser was the loss.

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Induction of Sexual Sterility in Indian Housefly, *Musca domestica nebulo* Fabr. Musharraf A. Ansari (Zoology Department, Aligarh Muslim University, Aligarh, India.) Received April 13, 1973. *Botyu-Kagaku*, 38, 135, 1973.

20. イエバエにおける不妊化の誘発 Musharraf A. Ansari (Aligarh Muslim 大学 動物学教室) 48. 4. 13 受理

イエバエに apholate, tepa, metepa を食餌混合投与，局所塗布，ペトリ皿内面塗布しての飼育の三方法によってテストし不妊効果をしらべた．

食餌に0.03125% tepa を混合して飼育したときには，100%の不妊化がみられた．局所塗布では，apholate, tepa, metepa がそれぞれ0.25, 0.0625, 0.5%の溶液 0.0018m*l* で，100%の不妊化がみられた．

Sc50 (sterility concentration 50) から各不妊剤の効力を比較したところ tepa は apholate の4.1倍，metepa の14.3倍，hempa の73.3倍，hemel の133.3倍であることがわかった．

また，おのおのの不妊剤をペトリ皿内面に塗布してイエバエ成虫を入れ接触させただけでも不妊効果があり，この方法でも tepa が最も効力があった．

The successful eradication of *Cochliomyia hominivorax* from the island of Curacao (Baumhover, *et al.*, 1955), Florida and South Estern States (Lindquist, 1959 and Knipling, 1960) gave a great impetus to the use of sterile males for insect control. Increasing attention is being paid to chemical sterilization approach advocated by Knipling (1955, 1959 and 1962) and Lindquist (1961) and a number of chemicals have been already shown promise as sterilants against *M. d. domestica* (Labrecque, 1961 and Labrecque *et al.*, 1960, 1963) when administered in the food of adults.

Of the various ways the chemosterilants act, the most interesting is that shown by radiomimetic compounds which completely destroy the genetic material of reproductive unit without affecting much the vigour and mating requirements of