مجلة جامعة تكريت للعلوم الزراعية المجلد(12) العدد(2)–(2012) - عدد خاص بوقائع المؤتمر العلمي الرابع لعلوم الثروة الحيوانية
ISSN-1813-1646

Biological control of house flies using indogenous ptermalid parasitoids in egg-layer facilities in Alberta

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KeyWords: Biological,house,alberta

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Abstract

The efficacy of the pupal parasitoid, *M. raptor* for the control of the house fly, *Musca domestica*, was evaluated in three egg-layer poultry farms in Alberta. Shallow and deep pit system egg-layer houses were used. Two houses in shallow pit system were designated as treatment and the other two houses designated as the control. In the deep pit system one house for treatment and one for control was used. Parasites were released at two-week intervals at the rate of 10-parasites/ hen. Fly populations were monitored bi-weekly by using sticky ribbons, baited-jugs, and index cards. There was a significant difference ($P<0.05$) between house fly numbers captured or trapped between the cold and warm seasons. Fly populations declined during cold season. The results suggested that the periods of warm weather, adversely affected parasitoids as well as other flies such as Calliphoridae. The percent parasitism varied between the deep pit and shallow pit poultry houses. The rate of parasitism ranged from 4% to 21 % in the shallow pit system and from 6% to 15% in the deep pit system. This study clearly demonstrates the effectiveness of *M. raptor* as biological control agents for house fly control especially in the deep pit system of the caged-layer poultry houses. Although early colonization of *M. raptor* in the shallow pit caged-layer poultry system was observed but the parasite populations did not maintained adequate densities in the houses to control flies. Also, the parasitism rate was low in shallow pit systems compared to that in deep pit systems. Therefore, sustained release of *M . raptor* can be recommended as an integrated part of fly management program for caged-layer poultry houses. Such a program must include, maximum efforts to reduce fly breeding by regular manure management practices, which promote drying of the manure and encourage breeding of large populations of variety of indigenous natural enemies of flies. *M.raptor* would be quite compatible in an integrated pest management program with predatory beetles and mites, as these would be seeking fly eggs and larvae and not be competing with parasites for fly pupae.

المكافحة البايولوجية لذباب المنزل باستخدام سلالات محلية من الدبابير في حظائر الدجاج البياض في البيرتا

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الخلاصة

تم تقدير فعالية التطفل لـــ(*M. raptor*) على عذارى ذبابة المنزل (*Musca domestica*) في ثلاثة حقول للدجاج البياض في البرتا، كندا. استخدمت في الدراسة بيوت التربية ضحلة وعميقة الارضية للفضلات. تم تصميم التجربة على ان تكون اثنين من البيوت ضحلة العمق للارضية كعينات دراسة بينما اعتبرت الانواع الاخرى كعينات ضابطة. اما البيوت عميقة الارضية فاحدها اعتبر عينة الدراسة وتم المقارنة مع النوع الاخر كعينة ضابطة .اطلقت الطفيليات لفترة اسبوعين بمعدل 10 طفيليلت لكل دجاجة. تم متابعة تجمعات الذباب مرتين اسبوعياً باستخدام الاشرطة اللاصقة، مصائد الحشرات، والبطاقات الاسترشادية.اظهرت النتائج ان هناك فروقا معنوية ($p< 0.05$) بين ذبابة المنزل المصادة او المحتجزة في فصول السنة الحارة والباردة، اذ انخفض عدد الذباب في الفصل البارد. نتوقع من هذه النتائج ان فترة الجو الحار قد اثرت بشكل سلبي على الطفيليات بالاضافة الى انواع الذباب الاخرى مثل (Calliphoridae).تفاوتت نسب التطفل بين بيوت التربية ضحلة الارضية والعميقة منها، اذ انحصر معدل التطفل بين (4% الى 21%) في البيوت الضحلة بينما كان المعدل في البيوت عميقة الارضية (6% الى 15%). اظهرت الدراسة بكل وضوح الى ان التاثير الفاعل لـــ *M. raptor* كعوامل مكافحة حيوية للسيطرة على ذبابة المنزل خصوصاً في اقفاص تربية الدجاج عميقة الارضية. بالرغم من ملاحظة تجمع مستعمرات الطفيلي المبكرة في البيوت ضحلة الارضية، الا ان تجمعات الطفيليات لم تتنظم في كثافات كافية في الاقفاص للسيطرة على الذباب. كما ان معدل التطفل كان قليلاً في البيوت ضحلة الارضية. لذا فان الاطلاق الثابت من (*M. raptor*) ممكن ان يوصى به كجزء متكامل لبرامج الادارة في بيوت الدواجن القفصية ذات الطبقات. مثل هكذا برامج يجب ان تتضمن الجهود القصوى للحد من تكاثر الذباب من خلال اداة الممارسات للسماد الطبيعي التي تدعو الى تجفيف السماد وتشجع تكاثر اعداد كبيرة من التجمعات المتنوعة من الاعداء الاصلية الطبيعية من الذباب.استخدام (*M. raptor*) سيكون توافقياً الى حد كبير للتكامل مع برنامج مكافحة الخنافس اللصوصية والقمل التي تستهدف بيض الذباب واليرقات ولا تتنافس مع الطفيليات على شرانق الذباب.

الكلمات الدالة : المكافحة البايولوجية ، سلالات محلية دجاج البياض

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Introduction

Several species of flies belonging to the genera *Musca*, *Hydrotaea*, and *Stomoxys* are common fly pests associated with poultry and livestock facilities. The build -up of manure and warm environmental conditions within livestock and poultry facilities provide an ideal habitat for fly development (Bennet, 1997). Accumulated manure in confined livestock farms is also a potential source of disease organisms harmful both to confined animals and to humans (Anonymous, 1975). Among dipteran species, the house fly *Musca domestica* has an important role as a disease vector (Aberg-Cobo et al., 1959). The behavior of this fly is typically synanthropic and because of its high reproductive rate and ability to inhabit a wide range of environments, it pullulates throughout the entire year (Crespo et al., 1998). In addition to diseases transmission, house flies regurgitate where they land causing brown spots. Eggs with high number of spots may be downgraded (Bennet, 1997). The economic losses due to housefly and stable fly are as high as $8 -$10 million annually in Alberta (Floate and Lysyk 1998). As house flies prefer to live in human and animal shelters, their presence in huge numbers in confined animal facilities irritate employees, reduce aesthetics of handling facilities and spread diseases. Nuisance complaints regarding the invasion of flies from neighbors of large livestock facilities in the central Alberta are on the increase and this will increase with more intensive livestock operations. In recent years, integrated pest management (IPM) for houseflies have become more widely used. This system utilizes all suitable techniques in a compatible manner to reduce pest populations and maintain them at levels below that causing economic injury. Integrated control achieves this ideal by harmonizing techniques in an organized way by making control practices compatible, and by blending them into a multi-faceted, flexible, evolving system. Interest in using biological agents is growing as a result of increasing resistance of flies to pesticides (Meyer and Georghiou 1987, Scott et al. 1989), increases in the price of new insecticides and the decreasing availability of older pest control products. (WareI983). Biological control systems offer a good strategy in reducing the cost of integrated pest management (Lazarus et al. 1989 and Noronha et al. 2007).

Research on the use of pupal parasitoids to control houseflies and stable flies in the United States has been extensive. The use of pupal parasitoids for fly control has spanned more than three decades but there have been few successes (Bennet 1997). The effectiveness of the parasitoids in controlling flies is under debate and some researchers report that they are effective (Morgan and Patterson 1979; Rutz and Axtell 1979) while others report they are not effective (Petersen et a. 1983). There are many factors that limit the effectiveness of the pupal parasitoids such as climate, wasp species, number of releases, and microhabitat conditions. Like most pteromalid wasps, *Muscidifurax raptor* and *Urolepis rufipes* are solitary endoparasitoids of muscoid pupae, including that of *M. domestica* and black garbage fly *H. anenescens.* Adult females oviposit a single egg within a fly puparium. Sometimes females may also probe a fly pupa for the purpose of feeding and not for oviposition. Such feeding results in additional host mortality and is known as residual mortality (Bennett, 1997; Float et al., 1998 and Stenseng et al. 2003). Floate. et al. (1999) have successfully identified ten native parasitic wasps in Alberta as potential biological control agents of flies including Musca *domestica.* Two promising species of parasitic wasp *(Muscidifurax raptor* and *Urolepis rufipes)* cultures have been maintained and mass produced in the Animal Industry Laboratory, Edmonton for the purpose of evaluation of their biological control potential in controlling houseflies in the confined animal raising facilities. The duration of parasitoid development in fly pupa is temperatures dependent. Complete

development egg to adult of *Muscidifurax raptor* can occur in approximately in 15 days when temperatures are above 30^0 C. However, when temperature is between 2021^0 C, parasitoid development occurs within 21-30 days (Mann et al., 1990). The entire development of the wasp takes place in a protected environment inside the fly pupa. In three to four weeks' time a new wasp will emerge and start searching for house fly pupae to parasitize. Because parasitoids develop slower than flies, they must be released weekly when used to control flies to ensure the presence of a continuous population of adult wasps, which in time can parasitize the pupa. Rutz and Axtell (1981) found seven species of house fly pupal parasites recovered from house fly pupae exposed in broiler-breeder poultry houses in North Carolina. Weekly release of Muscidifurax *raptor*, resulted in a significantly higher rates of house fly parasitism and a significant reduction in house fly population at the release farm, compared to the farm without parasite release. In caged layer poultry houses, sustained weekly releases of Muscidifurax *raptor* resulted in a significant increase in the rate of' parasitism of house fly pupae, towered the end of the season, and a higher proportion of *Muscidifurax raptor* in the parasite population, compared to farms where no releases were made (Rutz and Axtell 1979). They found reduction in house fly populations with concurrent parasite releases in narrow-caged layer houses. There was no evidence of reduction in high-rise cage-layer houses. House fly populations were monitored with sticky ribbons, baited traps, and spot cards. House fly pupal samples were collected and reared for determining parasitism rates.

A major advantage of using native parasitic wasps over commercially available parasites from Arizona and California is that they are active in cooler summer months and over winter in sub-zero temperatures and sustain their population. For these reasons, the most promising species of fly parasites *Muscidifurax raptor* was chosen.

Objectives

This study aimed to introduce and promote an alternate pest management strategy for fly control in egg-layer operations in Alberta, and to study the performance of *Muscidifurax raptor,* in parasitizing house fly pupae. The study also evaluated the impact of mass releases of native fly parasites, *Muscidifurax raptor* on house fly control in egg-layer cage operation in Alberta.

Materials and Methods

Experimental Farms

The experiments were conducted on three caged-layer farms located in St. Albert, Ponoka and Lacombe, Alberta.

St. Albert Farm

A large commercial egg-layer operation 30 km noth of Edmonton was used for the parasite sustained release study. Four egg-layer barns with similar feeding and manure management systems with holding capacity ranging from 6,000 - 12,000 hens were used.

Houses were 15mx50m- 15mx40m with four rows of cages with shallow concrete pit beneath, and a raised concrete walkway between the rows. Dropping boards were located directly beneath each row of cages. Manure dropped onto the shallow pit beneath the cages. Automatic feeder and waterers were used. Feed troughs were in the front of each tier of cages for the entire length of the row.

Manure was removed from the houses on irregular bases, as a result crust of manure was formed around the edges of the gutters and walkways. The manure was removed by pumping into a lagoon.

Two barns served as control (untreated) in which no house fly management techniques were performed, and two others served as treatment barns with biological agent *M. raptor*.

Ponoka Farm

A large commercial egg-layer operation 80 km south of Edmonton was used for the parasite sustained release study. Two egg-

layer barns with similar feeding and manure management systems \vith holding capacity ranging from 6,000 - 10,000 hens were used. Houses were 9m x 80 m with three rows and a deep concrete pit beneath the cages. A raised wood and steel walkway between the rows separated the rows of cages. Dropping boards were located directly beneath each tier of cages. Manure dropped onto these boards and then onto the deep pit beneath the cages.

Automatic feeder and waterers were used. Feed troughs were in the front of each tier of cages for the entire length of the row.

Houses were cleaned and free of manure when new birds were housed. When the treatment evaluations began, manure had accumulated under the cages for more than three weeks. But, manure was removed from the barns on irregular bases of time by shoveling it outside the barns.

One bam served as control (untreated) in which no house fly management techniques were performed, and other one served as a treatment barns with biological agent *M. raptor*.

Lacombe Farm

A large commercial egg-layer operation 80 km south of Edmonton was used for the parasite sustained release study. Two egg-layer barns with similar feeding and manure management systems with holding capacity ranging from 6,000 hens were used.

Houses were 9m x 60 m with three rows with deep concrete pit beneath the cages, and a raised wood and steel walkway between the rows of the cages. Dropping boards were located directly beneath each tier of cages. Manure dropped onto the deep pit beneath the cages. Automatic feeder and waterers were used. Feed troughs were in the front of each tier of cages for the entire length of the row.

When the evaluations began, houses had manure, which was less than one year old. Manure was very wet and some spots covered with water. Manure was removed after seven months of the commenced date of the experiment.

One barn served as control (untreated) in which no house fly management techniques were performed, and other one served as treatment barns with biological agent M raptor.

House Fly Rearing Method

A laboratory colony of housefly was established to provide regular supply of fly pupae needed for wasp production. Stock material of flies was collected from the University of Alberta Poultry Research Unit in Edmonton. The adult flies were kept in 30.5 cm cube-cages that were constructed from 2.5 x 2.5 cm thick lumber. The top, two side and the back of the cube was covered with nylon window screens. The bottom was constructed with a solid plywood base. The front frame was covered with nylon stocking for placing food inside the cage and also for collecting eggs. The flies were fed with a sugar/milk powder mixture (70:30), and a cup of water. The fly eggs were collected daily in moist growing medium placed in plastic cups. The fly larval rearing medium was prepared using oat-hulls and Calf-Mana (commercial dairy calf feed pellets manufactured by Mana Pro Partners, 1. P., 4548 Madison Street, Denver, Colorado, 80216, USA.) mixed in 20 liters bus-pans generally used in restaurants and water was added to the mixture. Each bus-pan was seeded with 5000 fly eggs (10 ml eggs suspended in water) and incubated at 27 0 C temperature. The eggs would hatch and develop into larva and reach the pupal stage in 5-6 days. At this stage the medium was submerged in water and the floating pupae were skimmed off the top using a metal strainer and placed in new cages for emergence.

Source of Native Parasitic wasps

Stock material of *M. raptor* was reared from house fly pupae that were collected in feedlots near Ponoka and Lacombe, Alberta. They were maintained at the Animal Industry Laboratory in Edmonton in separate insectary rooms. Freeze-killed house fly pupae were used as a host for growing these parasitic wasps.

Parasitic Wasp Rearing Method.

The adult *M. raptor* parasites were kept in Plexiglas cages 42 cm long, 36 cm wide and 32 cm deep. Two 10 cm round openings on the sides were covered with fine muslin cloth for air exchange. One large 15 cm round opening covered with a thick organdy cloth sleeve, generally used in filtering honey. Freeze-killed house fly pupae were placed in 12 x 15 cm nylon window screen bags and kept for 24 hours for allowing wasps to sting or parasitize fly pupae(Geden and Kaufman; 2007).

Treatments

The treatments were the biological and control barns with no treatments. Treatments and control assigned to the barns were as follows:

A) St. Albert (July 1999 - April 2001)
Two barns as control and two barns treatment with *Muscidifurax raptor*

B) Ponoka (November 1999 - April 2001)
One bam as control and one as bam treatment with *Muscidifurax raptor*

C) Lacombe (June 1999 - April 2001)
One bam as control and one bam as treatment with *Muscidifurax raptor*

Parasite Releases

The parasites were released every two weeks. Parasite release commenced from the first week till the final week of the experiment (July, 1999-April, 2001). The parasites were released at the rate of 10 parasitoid / hen /2 weeks. About 50,000 and 100,000 parasites were released in barns according to the hen's number. The parasitized pupae were placed in 17x25 cm window screen nylon bags and attached to the posts in the vicinity of the pit at about 3cm from the floor. Total number of parasites released for each bam during the experiment ranged from 2,300,000-4,600,000 parasites.

Fly Monitoring

Indirect methods of fly counts were used to determine the fly activity from first week up to the final week of the experiment. The indirect fly counting method consisted of unlined spot cards (7.5cm x 12.5 cm white index cards); seven per each poultry house were attached to the wall at about 10m intervals where flies congregate. These cards were exposed for two weeks and replaced with new ones. Number of fly specs, which consisted of both fecal, and regurgitation spots left by the resting flies on the cards were used as an index of fly activity for the duration of the week (Rutz and Axtell 1979). Flies were also monitored with sticky ribbons, according to Lysk and Axtell (1986). The sticky fly ribbons were 66 cm long and 4 cm wide. They were hung from the ceiling. Seven ribbons were set up in each poultry house. Data was recorded as flies/ribbon/2weeks.

Sentinel Pupae

Two small nylon screen bags measuring 10cm x 10cm with 100 two day old freezekilled pupae were used as sentinel pupae. The bags were hung 1 m above the pit at two ends of the bam. The sentinel pupae were exposed to the wasps in the barns to measure the degree of parasitism that occurred during that week. At the end

of two weeks, the bags were replaced with new ones. The pupae were taken to the laboratory and held in petri dishes for 30 days for emergence of parasitoids, at which percent parasitism was calculated. The parasite release site was the center of the room and away from the sentinel pupae bags.

Baited-jug Traps

The baited-jug traps were suspended from the ceiling and were used as fly monitoring stations. This method facilitated the collection of dead flies prevented the contamination of manure in the pits with insecticide, where the parasitic wasps will be searching for fly pupae to parasitize. Commercial Apache insecticide bait (1 % Methomyl) was selected for use in the bait stations. The bait-stations were made of empty four-liter milk jugs. Three, 8 em diameter holes were cut on the sides in the middle wider part of the jug. Seven jugs were hung from the ceiling using screw-hooks and wire. Two tablespoons of bait was added to the container. At the end of the two weeks, dead flies that were killed and accumulated in the jars were collected and counted.

Statistical Analysis

The effects of parasitoids released were analyzed by PROC GLM (General Linear Models) procedures. The factors were the treatments (biological) *M. raptor* and control (untreated). Seasons: cold season (fall and winter) and warm (spring and summer) and three locations (St. Albert, Poona, and Lacombe). Statistical analyses were performed using SAS (SAS users guide 1985: statistics. SAS Institute, Cary NC. 1042 pp.).

Results and Discussion

Flies Captured by Sticky Ribbons and Baited-jug Traps

Results of fly counts captured by ribbons and trapped by using baited-jugs are shown in Tables I, 2 and Figure I, 2. Based on two weeks observations of flies using sticky ribbon, fly counts were significantly different ($P < 0.01$) between the deep pit and shallow pit system. Density of adult flies in shallow pit was 62 flies/ribbon, where as in control barns fly counts were 107-flies/ ribbons. Flies captured by ribbon in the deep pit were 24 flies/ribbon in treatment barns, and 48 flies/ribbon in the control barns. Results from the poultry houses with deep pit, where parasite were released, showed a lower level of house flies trapped from the beginning of the experiment up to the end when compared with the number of flies trapped in control barns.

In shallow pit barns, where parasites were not released, showed fly captures were higher at the beginning of the experiment in July up to the end ofthe experiment. The highest levels occurred from April to June. In treatment barns, where parasites were released levels of flies were decreased rapidly and almost maintained at the lower levels compared with the control.

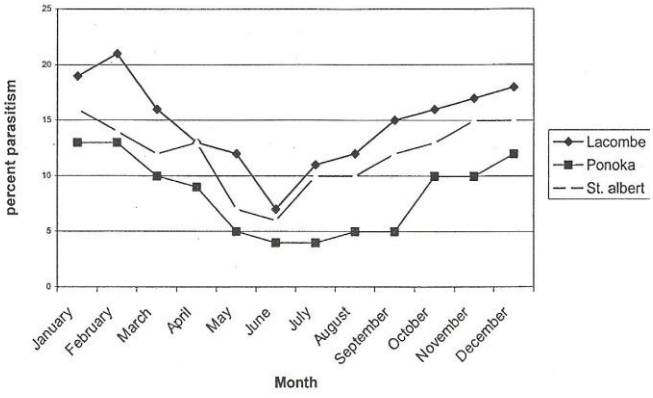

Fig. 1. Number of flies captured by sticky ribbon in shallow and deep pit barns during the study period.

The sticky ribbons were very effective in trapping flies, even when the fly populations were low. But, when populations increased to higher levels, the ribbon trap completely

covered with flies and become less effective in capturing flies.

The fly numbers trapped by using baited-jugs were significantly different between deep and shallow pits. Flies captured in shallow pit barns were higher than fly numbers
captured in deep pit, 86 and 25 flies / baited-jug, respectively. Fly catch were low in the deep pit poultry barns. Small dung flies were also caught in the traps, but at much lower levels than those caught on the ribbons.

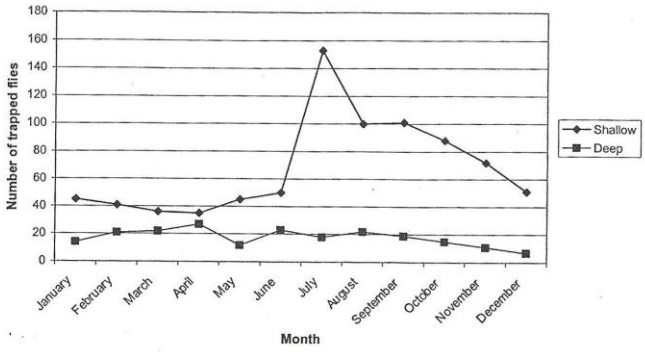

Fig. 2 Number of flies trapped by baited-jug in shallow and deep pit barns.

In the control barns, where parasites were not released, the control barns fly umbers were initially moderate during January to May and the numbers increased in June and July and also remained at higher numbers until the end of the experiment in December. Captured flies peaked in August, this peak generally corresponded with those found in sticky ribbons.

In the deep pit barns, where parasites were released, the overall fly numbers were lower and a slight decrease occurred in the month of July.

Fly Spots

Results of the mean number of fly spots per card monitored at two-week interval are shown in Table 3 and Figure 3. The mean number of fly spots per card was similar in the deep and shallow pits. The numbers were, 8 spots / card. The treatment barns with the deep pit system fly spots were very low levels from the starting month of the experiment with exception for small peaks. This trend also, shown in ribbon and bait - jug traps confirmed that overall fly populations were low.

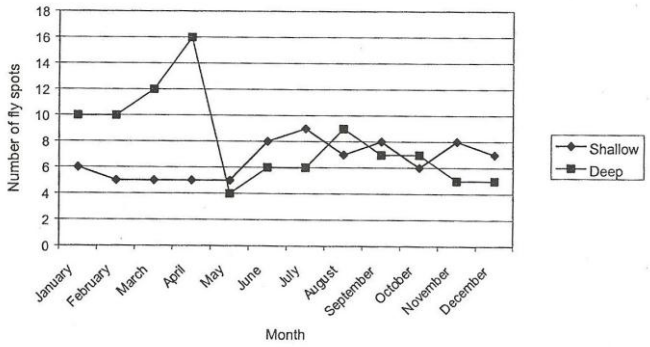

Fig. 3. Number of fly spots in shallow and deep pit barns.

In general evaluation in all farms was sometime difficult due to leaking water
causing wet manure, use of chemical to kill adult flies, and complete removal of manure on irregular basis. Although the sticky ribbon was sensitive to trap flies, even when fly populations were low. But when populations increased to high levels, the entire area of ribbon covered with flies and they become less effective in capturing more flies. Furthermore, in many cases the ribbons were not effective in trapping flies because of the high level of dust in the barns, and also thousands of small dung flies trapped on to the ribbons. In addition to that, occurring of Calliphorids, the carrion breeding flies which complicated the house fly sampling. Therefore, fluctuation in flies captured or

trapped may be due to these management practices that influence the effects of parasitoids.

Season

Fly populations in each farm were variable and generally declined during the cold season. There were significant differences between the fly number captured by ribbons in cold and warm seasons. The apparently lower fly numbers 48 flies/ribbon captured in treatment barns during cold season. While 62 flies/ribbon were captured in control barns at the same season. During the warm season, flies number increased and reached 63 / ribbon in treatment barns and 73 flies / ribbon in untreated barns. Baited-jug traps during warm season captured more flies 62/baited-jug, while during cold season number of flies captured were 50 /baited-jug. Season has some effects on spot numbers as well. During cold season number of spots/card were 7 and 10/card during the warm season. The increased of flies during warm weather may be due to increasing use of manure pits and lagoon, Sweeten 1980, suggests that such wet outdoor habitats may increasingly contribute to fly production very effectively during warm weather. The results suggested that periods of warm
weather, adversely affected both parasitoid, and possibly affects other species as well. This finding brings into question the use of these agents during the warmer portion of season. Petersen et al (1995) reported similar results on their study on *M. zaptor* used at four beef cattle feedlots in eastern Nebraska.

Parasitism

In shallow pits *M. raptor* were recovered during the release period in all four houses. The results suggest the *M. raptor* may be an early colonizer of poultry houses because it was found in all houses we investigated, but at the same time did not maintained high densities in all houses. During the prerelease period, the average percentage of house fly pupae parasitized by *M. raptor was* 6 %.
In deep pit-houses, M. *raptor* was not recovered during the pre-release period in any of the houses in both farms.

Parasitism rate of pupal samples, from houses where parasite was released in shallow pits is listed in Table 4 and Figure 4. Parasite had first been released in July. Therefore, some native parasites were present. Parasitism increased from 6% during the pre-released sampling to the highest levels during December-February in the I" and 2nd year of experiment. Percentage parasitism of sentinel pupae during the same period ranged from 13-16. Percent parasitism of sentinel pupae began decreasing more with arrival of warm season. Although some parasites were present on the farm, but they were unable to produce numbers adequate to control fly populations. However, adequate numbers can be provided with sustained releases. Such a method of pest management will decrease the use of insecticides.

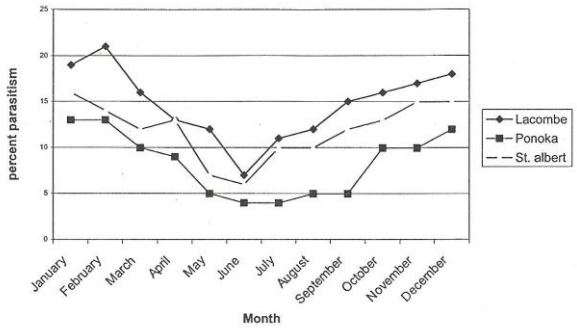

Figure 4. Percent parasitism of house fly pupae in poultry houses using sustained releases of parasite *(M. raptor)* as biological control agent.

In deep pits, *M. raptor* was not recovered during the pre-released period in any of these houses under investigation. Parasitism rate increased to moderate levels, especially in Lacombe farm. The percentage parasitism reached the highest levels in February 22. The peak of parasitism started during December-February. Also, the level of parasitism began decreasing with arrival of the warm season Table 3. Parasitism rate in other deep-pit houses was less than in the Lacombe. The management practice in Lacombe might have promoted the parasite establishment and other methods of biological control, which increased the parasitism rate.

Evaluating the direct impact of parasite release on naturally occurring fly pupae in the barns is difficult. The use of sentinel pupae permits a controlled sampling procedure guaranteeing a sample of exposed hosts. However, artificial placement of pupae may preclude them from being encounter by searching parasites or may allow them to be parasitized more readily than pupae in natural habitats. In our study we did not sample naturally occurring fly pupae because pupae often are not available in sufficient numbers, or may be too young (not exposed to parasite for their entire susceptible periods, or may too old, which sometimes results in overestimates of parasitism levels (Petersen, 1986). Although, parasitoids were released in the middle of barns, which provided very uniform distribution of parasitoids as they emerged. But in many cases one bag was attacked, this suggest that the overall pattern of incidence of parasitism is influenced more by the difficulty of locating hosts than by any tendency to remain or aggregated at patches. This theory is further supported by the low proportion of sentinel bags attacked by parasitoids 10 % by *M. raptor* and 4.5 % by U. *rufipes* (Smith and Rutz, 1991). The sentinel pupae bag technique is the least problematic, in regard to the interpretation of the rates of parasitism, of the possible methods for sampling parasitoids (petersen and Meyer 1983, Rutz 1986). Previous studies suggest that the mesh dose not interfere significantly with oviposition (Smith et al. 1989). Crespo et al (1997) reported the percent of parasitism for *M raptor* and *Splangia endius* (walker) was almost 100% for several weeks of the trial, and both species were recovered in almost equal numbers. Morgan et al (1981) recorded similar parasitism levels when releasing S. *endius* and *M. raptor* together. However they recovered very few *M. raptors.*

It should be noted that we used an indigenous strain of *M raptor* since parasite must be climatically adapted to the area where they are released (Legner and Olton, 1971; Tingle and Mitchell 1975), it is possible that a parasite species acquired from one geographic region will not be effective when released in another climatically different area. Unless it is established experimentally that the parasite is effective in the area of introduction, shipping parasite from one climatic region to another is a questionable procedure.

Our study showed a difference **in** the effectiveness rate of the parasite **in** the mean of parasitism rate between the cold and warm months of the year. Morgan et al1981 reported that *M. raptor* wasps appear reluctant to fly from the release site stations to fly breeding area, a distance of ca. 3 m. This tendency to remain **in** the shelter or the release stations may have been response to the high time temperature during warm seasons.

Pupal parasitoids, based on this study have a low to moderate effects on fly populations. It might be possible to increase the effectiveness of parasitoids by increasing the number of wasps released into the barn within a short period of time.

Sustained release of *M. raptor* is logical part of a fly management program for caged-layer poultry houses. Such program must include, however, maximum effort to reduce fly breeding by manure management practices which promote drying and large populations of variety of indigenous natural enemies of flies (Rutz and Axtell 1979). Also, Rutz and Axtell (1981) reported a weekly sustained release of indigenous strain of *M raptor* resulted in a significantly higher rate of house fly parasitism, concurrent with a
significant reduction in the house fly population at the release farm in comparison to farms without parasites release.

In addition to the sustained release of wasps, management practice of manure removal could have an impact on the fly population, by promoting parasite establishment and other methods of biological control. Axtell (1986) suggested some management practice outline that can help in biological control program to reduce fly populations. These suggestions include allowing the manure to accumulate to allow a population buildup of naturally occurring parasites and predators. The complete removal of manure should not be done. A base of old manure should be left be left behind to encourage predators and parasites and to assist in absorbing excess moisture from the newly added droppings. Axtel also suggested that manure should be partially removed over a period of a few weeks rather than all at once.

The effectiveness of sustained release of *M raptor* for house fly control has been demonstrated in this study especially in deep pit farm of caged-layer poultry houses.
In spite of early colonization of *M. raptor* in the shallow pit caged-layer poultry farm, but did not maintain high densities in the houses. Also, the parasitism rate was low in comparison to that in deep pit houses.

Therefore, sustained release of *M.raptor* is logical part of fly management program for caged-layer poultry houses. Such a program must include, however maximum effort to reduce fly breeding by manure management practices which promote drying and large populations of variety of indigenous natural enemies of flies. *Mraptor* would be quite compatible in an integrated pest management program with predatory
beetles and mites, as these would be seeking fly eggs and larvae and not competing with parasites for fly pupae.

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Table **1.** Number of flies / ribbon captured during two weeks of observation in shallow pit and in deep pit barns.

Month	Shallow pit		Deep pit	
	Control Mean ±SE(n)	**Treatment** Mean±SE(n)	**Control** Mean ±SE(n)	**Treatment** Mean±SE(n)
January	97± 6(28)	45±6(28)	29±7(31)	l4±3(28)
February	88±5(28)	41±6(28)	27±6(33)	21±6(28)
March	91±5(28)	36±6(28)	29±6(32)	22±5(28)
April	110±6(28)	35±4(27)	34±7(32)	27±4(28)
May	ll8± 9(14)	45±6(14)	40±13(16)	l2±4(14)
June	97±7(14)	50±6(14)	36±9(25)	23±5(21)
July	79±11(28)	153±70(28)	43±9(24)	18±3(21)
August	81±12(28)	100±9(28)	48±9(24)	22±S(21)
September	113±12(28)	101±ll(28)	28±7(32)	19±3(21)
October	121±7(28)	88±11(28)	31±7(32)	15±2(21)
November	118±5(28)	n±9(28)	26±6(32)	11±2(28)
December	104±5(28)	51±6(28)	22±6(33)	7±0.9(28)

Table 2: Number of flies / baited-jag trapped during two weeks of observation in shallow pit and in deep pit barns.

Month	Shallow pit		Deep pit	
	Control Mean ±SE(n)	**Treatment** Mean±SE(n)	**Control** Mean ±SE(n)	**Treatment** Mean±SE(n)
January	43±6(25)	99±5(14)	32±7(31)	21±5(25)
February	39±5(25)	50±4(25)	37±7(33)	33±10(25)
March	40±6(25)	97±4(25)	44±9(32)	39±10(25)
April	37±4(27)	124±5(25)	61±11(32)	46±3
May	37±4(14)	125±6(l4)	66±17(16)	11±3(14)
June	46±5(14)	134±5(14)	52±9(25)	15±3
July	63±10(27)	96±9(25)	54±11(24)	22±4
August	110±1(25)	111 ±11 (28)	61±13(24)	27±
September	100±11(28)	114±8(28)	42±7(32)	20±3(21)
October	81±8(28)	114±5(28)	32±7(32)	15±3(21)
November	70±8(28)	112±5(28)	33±6(32)	11±2(28)
December	47±6(28)	103±4(28)	15±5(33)	9±1(28)

Table 3: . Number of flies spots / card deposited during two weeks of observation in shallow pit and in deep pit barns.

Month	Shallow pit		Deep pit	
	Control Mean ±SE(n)	**Treatment** Mean±SE(n)	**Control** Mean ±SE(n)	**Treatment** Mean±SE(n)
January	7±1(28)	6±.9(28)	9±3(31)	10±2(28)
February	7±l(28)	5±.8(28)	9±3(33)	10±3(28)
March	8±1(28)	5±.(28)	9± 3(32)	12±2(28)
April	11±1(28)	5±.9(27)	13± 4(32)	16±3(28)
May	l2±2(l4)	5±l(14)	14±5(16)	4±1(14)
June	14±1(14)	8±.8(14)	6±1(25)	6±1(21)
July	13±2(28)	9±2(27)	8±1(24)	6±l(21)
August	l6±3(28)	7±1(28)	l6±4(24)	9±1(2I)
September	19±3(28)	8±1(28)	8± 2(32)	7±l(21)
October	l2±2(28)	6±.9(28)	32±7(32)	7±1(2I)
November	9±1(28)	8±1(28)	33±6(32)	5±l(28)
December	8±1(28)	7±.9(28)	15±5(33)	5±.7(28)

Table 4. Mean percent of parasitism rate in the three farms.

Month	Deep pit Ponoka	Deep pit Lacombe	Shallow pit St. Alberta
January	13	19	16
February	13	21	14
March	10	16	12
April	9	13	13
May	5	12	7
June	4	7	6
July	4	11	10
August	5	12	10
September	5	15	12
October	10	16	13
November	10	17	15
December	12	18	15