

“More Than Two”: Integrating Biological Control and Sterile Insects, from Factory to Field, and the Possibility of its Implementation in Argentina

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ABSTRACT: No single control measure is able to provide full control of a pest. Integration of techniques like the sterile insect (SIT) with biological control practices (BC) should be intensively sought for. This possibility is revised here in connection with the fruit fly pest problems in Argentina. Theoretical reasons as well as practical conveniences for this integration are reviewed in this paper, the intention of which is to promote a discussion on how to approach the experimental study of the SIT+CB integration problem, i.e. how to measure the effects of each separate control measure as well as that of both acting together, in a repeatable manner. Arguments are advanced in favor of the joint production and releases of sterile fruit flies and parasitoids.

Key Words: *Ceratitis capitata*, *Anastrepha fraterculus*, *Diachasmimorpha longicaudata*, genetic sexing strain, SIT+BC synergism

“.. Y EN LA CALLE, CODO A CODO, SOMOS MUCHO MÁS QUE DOS.” (“TE QUIERO” MARIO BENEDETTI)

Pest control practitioners are becoming increasingly aware of the fact that no single control measure is able to provide full control of a pest. For this reason integrating methods is becoming a common practice. Action programs against particular pests also have to deal with growing environmental concern from the society in general and from consumers in particular. Tolerance threshold for pesticide residues are becoming lower and lower and, at the same time, the number of cases reported of genetic resistance to chemicals keeps growing every year. Any form of biological control by natural enemies as well as any variant proposed of genetic control, like sterile or semi sterile insects, or population drive, clearly fulfills the required condition of being friendly to the environment. Under these premises, one would expect that the integration of sterile insect technique (SIT) with biological control (BC)

practices should be intensely sought for and, that this integration should become a focal point of interest for research laboratories investigating pest control in the world; curiously enough, it is not.

THE FRUIT FLY PEST

In the family Tephritidae (Diptera) there are several economically important flies causing damage to the production of a large number of plant species worldwide (Maddison and Bartlett, 1989). A number of studies on Systematics, Bionomics, Genetics and Control has been carried out for most of the economic important fruit fly species (see reviews by Cayol, 2000; Berlocher, 2000; Korneyev, 2000; Sivinski et al., 2000). In the present article we are mainly concerned with the fruit fly problem in Argentina.

FRUIT FLY PROBLEMS IN ARGENTINA

In Argentina, there are two quarantine species of fruit flies: the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), and the

South American fruit fly, *Anastrepha fraterculus* (Wiedemann) (Maddison and Bartlett, 1989). *C. capitata* is native to Africa and has a worldwide distribution, covering many tropical, subtropical, and temperate regions (Copeland et al. 2002), and showing high adaptability to diverse climates as well as a large number of host fruit species (ca. 350; Liquido et al. 1991). Its presence in Argentina was first recorded at the beginning of the 20th century in orchards located in the vicinity of Buenos Aires city (Vergani 1952). Later, it was reported in commercial orchards of northeastern and northwestern regions of the country. The last region in which it was reported was northern Patagonia (southern Argentina), where *C. capitata* was first detected in 1952 (Vergani 1952; Rial 1997).

A. fraterculus is native to South America and is distributed from Mexico to Argentina, but there is morphological and genetic evidence for the existence of sibling species within the taxon (Steck 1991, Hernández-Ortiz et al. 2004) and that not all the species within this species complex are pests (Aluja et al. 2003). In Argentina, *A. fraterculus* is mainly distributed in regions with tropical and subtropical climate (Ovruski et al. 2005). It is also a polyphagous species that attacks different families of fruit species, but the number of hosts cited is smaller (ca. 80 species; Norrbom 2004) than that for *C. capitata*. Both species cause significant annual losses to the Argentinian fruit production and constitute a major barrier to the expansion of this market (Ovruski et al. 1999).

COMPETITION BETWEEN THE TWO SPECIES

Segura et al. (2006) analyzed the relative abundance of *C. capitata* and *A. fraterculus* along different regions and different hosts in Argentina and they found that both species coexist there in several areas and hosts,

exhibiting similar ecological requirements. Therefore, strong competition should be expected between them in habitats where the resources are scarce, as in wild or urban habitats where the density of host plants is usually low. These habitats serve also as refuges for small populations that are usually neglected by traditional pest control measures becoming foci where re-infestation starts. Segura et al. (2006) conclude that future studies should focus on these habitats and produce more information for area-wide management of these pests.

METHODS FOR FRUIT FLIES CONTROL

In general, the methods more commonly used worldwide to control the fruit flies are chemicals, the sterile insect technique, and biological control, depending of the fruit fly species. There are studies (McInnis et al., 1994; Montoya et al., 2000; Robinson, 2000; Wong et al., 1991) integrating techniques in different levels – in the laboratory or in the field – but the general rule applies here: integration of SIT and BC for fruit flies control has been not enough investigated.

THE STERILE INSECT TECHNIQUE

The sterile insect technique (SIT), conceived in the 1930s by Knipling, and improved by Bushland and associates in the 1950s (Gilmore, 1989), is based on over-flooding the pest population along a significant geographic area with artificially reared and sterilized insects of the same species. The first successful experience including SIT in an area-wide integrated pest management program was in the 1950s, being this method used for many years in the USA, Mexico, and Central America, to eradicate a livestock parasite, the screwworm *Cochliomyia hominivorax* (Coquerel) (Klassen and Curtis, 2005).

FRUIT FLIES CONTROL WITH SIT

At present, the SIT is extensively applied against tephritid fruit flies. The first large scale program was developed in 1970s against *Ceratitis capitata* from Central America to southern Mexico (Hendrichs et al., 1983). Several countries have established complete or partially SIT programs against different species of fruit flies: Chile, Peru, Argentina, Brazil, Mexico, USA, Spain, Portugal, South Africa, Japan, Israel, Tunisia, and Thailand (Klassen and Curtis, 2005).

In Argentina, the sterile insect technique is being successfully applied to control *C. capitata* (Aruani et al., 1996; De Longo et al., 2000). The SIT implemented in Mendoza, and San Juan provinces, the Patagonia region, and more recently, in La Rioja, (De Longo et al. 2000, Sánchez et al. 2001, Frisolo et al. 2001), aims to eradicate *C. capitata*. However, SIT is also currently considered as a valuable tool in the suppression of this pest form other provinces with different ecological scenarios.

BIOLOGICAL CONTROL

The biological control (BC) has been defined by DeBach (1964) as the action of parasites, predators or pathogens in maintaining the population density of another organism at a lower average than would occur in their absence. In another vein, it could be define as the use of natural enemies to reduce to tolerable levels the damage caused by noxious organisms (DeBach and Rosen, 1991). Among the variants of BC proposed (classical, conservative, augmentative, etc.) the inundative parasitoid release – involving massive production and continuous release of insects – is comparable to SIT in many regards.

BC FOR THE CONTROL OF FRUIT FLIES

The idea that fruit flies could be controlled by augmentative releases of parasitoids at the appropriate phase of this pest life cycle, was advanced by Knippling himself (1992), following the usage, implemented from the beginning of last century, of parasitoids as natural enemies in BC strategies, but only in recent years systematic studies were performed on the biology and ecology, and specially on artificial rearing, of fruit fly parasitoids. Hawaii (Wong and Ramadan 1987), the continental USA (Sivinski et al., 1996) and Mexico (Montoya et al., 1998) are good examples of successful fruit fly BC programs with augmentative releases of parasitoids. In sum evidence is mounting that augmentative or inundative parasitoid releases may be an efficacious means of suppressing fruit fly populations.

As Ovruski et al. (1999) pointed out, compared to SIT, parasitoid wasps as biological control agents for fruit flies has received less attention in Argentina. However, a great deal of of basic information is available about native and exotic species with potential for the control of fruit flies in Argentina.

NATIVE

The first step towards obtaining, increasing and immediately releasing *A. fraterculus* indigenous parasitoids in Argentina were registered in areas covered with wild vegetation of the Misiones province, NE Argentina during the 1930's (Ovruski and Fidalgo, 1994). Also, during the early 1940's, native parasitoids were collected in wild vegetation and released in commercial citrus orchards of the Tucumán province, NW Argentina (*idem*). The biological studies of fruit fly native parasitoids for using them in biological control program in Argentina have been resumed in recent years (Ovruski 2002; Ovruski et al 2004, 2005; Ovruski and Schliserman 2003a,b).

EXOTIC

The first introduction of an exotic parasitoid for fruit fly biological control into Argentina occurred in 1947. The eulophid *Tetrastichus giffardianus* Silvestri was introduced into the country from Brazil for controlling *C. capitata* (Ovruski et al., 2000). In the 1960's a second effort was done for controlling medfly and also *A. fraterculus* by introducing five parasitoid species from Mexico (Ovruski and Fidalgo, 1994). Initial shipments were originated in Hawaii, via Costa Rica. The program involved small-scale productions of these three parasitoid species, and releases of limited numbers of specimens in Tucumán and Catamarca. Unfortunately, follow-up studies did not ensue (Ovruski et al., 1999). The permanent establishment of one of them, the Asian species *Diachasmimorpha longicaudata* (Hymenoptera: Braconidae) was recently reported by Schliserman et al. (2003) in Misiones. The most recent program was initiated in 1999, by introducing specimens of the braconids *Diachasmimorpha tryoni* (Cameron) and *D. longicaudata* into Argentina from Mexico. These parasitoids were successfully colonized on *C. capitata* larvae (Ovruski et al., 2003; Viscarret et al., 2006), but they have not been released in the field yet.

WHY SIT+CB?

The hypothesis of inter-specific competition between *C. capitata* and *A. fraterculus* should be carefully tested in Argentina. In this country, it would be very useful to be able to predict the response of *A. fraterculus* populations to a marked decrease in the density of *C. capitata* and to identify areas likely to experience an increase in the population of the former, thereby avoiding outbreaks of this pest. A focal point of interest should be to devise strategies for those areas where *C.*

capitata is suppressed by SIT while *A. fraterculus* is not. Complementing SIT for Medfly with BC for both fruit flies appears to be a highly advisable strategy in this context. But this is not the only argument in favor of integrating the BC into the on going SIT programs.

THEORETICAL REASONS

There are studies theoretically showing that (inundative) releases of parasitoids applied in conjunction with the SIT may have a synergistic effect to suppress pest populations. But, why should in theory SIT+BC sum up "more than two"? As Carpenter et al. (2005) put it on page 132, it is easy to see that, "although natural enemies and the SIT have different modes of action, the effectiveness of SIT increases the ratio of natural enemies to adult hosts, and the effectiveness of natural enemies increases the ratio of sterile to fertile insects". Numerical examples have been provided by Knipling (1992); his calculations, assuming the ratio of sterile insect as being 2:1 and the ratio of parasitoids as 6:1, conclude that the joint effect would be 130 times that of the SIT alone or, 8 times that of the parasitoids alone. Using inference models borrowed from infectious diseases, Carpenter (1981) pointed out that control measures that increase the pest "death" rate (e.g. pesticides) increase the threshold pest population required for a given pathogen to control the pest, whereas those control measures that decrease the pest "birth" rate (e.g. sterile males) do not interfere with pest regulation by pathogens. Barclay (1987), performing specifically designed simulations, concluded that two methods of pest control are able to complement when they are effective at different densities of the pest. Consequently, parasitoids being more effective at high densities, and sterile males being more effective at low densities, should complement.

PRACTICAL CONVENIENCES

Sometimes there are also practical reasons for this complementation to be convenient. The SIT requires pest numbers to be low, and action programs usually achieve this by spraying insecticides. BC could be applied instead, releasing the natural enemies as a “biological insecticide”; this would lower down the pest numbers before starting with sterile insect releases. Another example, in moths, instead of fully sterile males as in SIT, semi-sterile males are released for pest control, and the sterility is induced in the F1 generation. The final effect of pest suppression is the same. In programs like this, large numbers of sterile F1 larvae are produced in the field. This would provide an increased number of hosts for parasitoids. Experiments showed that female parasitoids show no oviposition preference for progeny when compared to female moths paired with either irradiated or unirradiated males (Mannion et al. 1994, 1995 Carpenter et al. 1996). Therefore, no doubt about the acceptability and suitability of the F1 progeny (of irradiated males and untreated females) as parasitoid hosts.

INTENTION

In the present article we intend to promote a discussion on how to approach the experimental study of the SIT+BC integration problem, in general, i.e. how to measure the effects of each separate control measure as well as their joint effect, in a repeatable manner. Naturally, we are also interested on what are the chances of integrating SIT and BC for control of the fruit fly problem in Argentina. This paper is an invitation to think together rather than a proposal on how to solve these issues. As a very important step in approaching any complex problem is to identify key or crucial points along the line, our contribution is also intended as a draft of an agenda

including some of the subjects that must be considered. Dividing the “big” question in smaller – more accessible – questions will be the first proposal that we would like to advance.

JOINT PRODUCTION AND RELEASES

Extended use of fruit fly parasitoids has in the past been delayed because mass rearing them is often relatively expensive. Unless we do something about this, their adoption in the future will be very limited. Another practical, and often overlooked, reason for integrating BC into SIT programs is that considerable savings could be gained by the simultaneous production and release of both commodities. On the one hand, the mass production of sterile males and parasitoids in the same factory may result in a considerable reduction of costs compared to producing these agents separately. On the other, the costs of the logistics for releases in the field could be almost halved. A pretty obvious division of the “big” problem is between the difficulties found trying to integrate SIT and parasitoids productions in the factory and, those coming from the implementation of an integrated SIT+BC strategy in the field.

INTEGRATING SIT+BC IN THE FACTORY

This problem of producing parasitoids at the same time as producing sterile males has to be focused, at least for medfly, in the perspective of the “genetic-sexing-strains” production, because this strains are presently ubiquitous in the world. As the efficiency of SIT improve significantly when only males are released (McInnis et al., 1994), nearly every sterile medfly producing facility in the world is rearing a genetic sexing strain and delivering males only. Testing a sexing strain as a rearing medium for the production of

parasitoids may be a good starting point in this context.

SOME EXPERIENCE IN ARGENTINA

There is a genetic sexing strain of *C. capitata* based on a separation by rate of development (see references in Delprat et al., 2002). In this strain, females have a longer developmental time than males so they can be separated (Viscarret et al., 2002) without being destroyed. While the male larvae could be used for the SIT after their emergence (previous irradiation at pupa stage), the slow developing female larvae could be used for rearing parasitoids to be released in BC programs (an idea first proposed for the Caribfly, *Anastrepha suspensa*, by Sivinski and Calkins, 1990). We have been rearing this strain at INTA Castelar, where the rearing facility is of experimental scale (50m²) but large enough to yield information about the kind of problems a “double purpose” factory, such as the one proposed here, will have to face. To do this, a 3-year (US\$25000/y) project funded by FONCYT-INTA was initiated in 2004. As one of the result of this Project, the Program in San Juan is now starting to rear parasitoids.

QUALITY OF THE PRODUCTION

Just illustrating aspects of the quality of flies reared in this facility, the evolution along the year 2005 of three parameters, are presented in the Figure 1. They are, egg to adult survival, pupa to adult survival (divided by 2, to place it in the same scale), and proportion of female larvae produced; note that the maximum expected for all three parameters is 0.50. Egg production, another factor affecting productivity, averaged 9.8 ± 2.4 eggs / female/ day (Figure 2), and the proportion of this eggs reserved to keep the colony aver-

aged $15.2 \pm 2.3\%$, meaning that nearly 85% of the eggs produced were available for other purposes: production of sterile male flies, cage experiments (see, below) or parasitoid rearing.

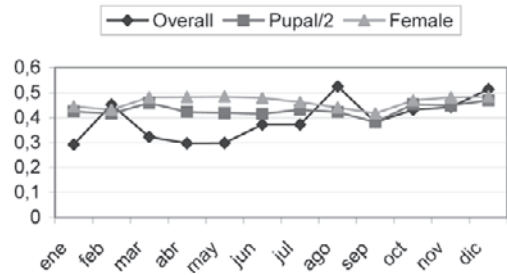


Figure 1. SURVIVAL. Egg to adult survival, pupa to adult survival (1/2), and proportion of female larvae produced.

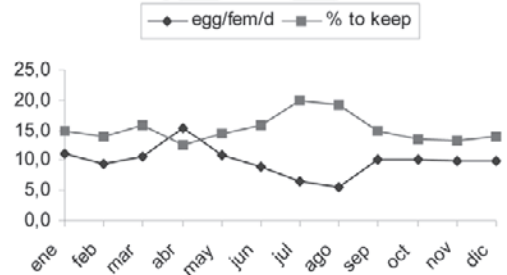


Figure 2. PRODUCTIVITY. Egg production, and proportion of this eggs reserved to keep the colony.

PRODUCING *C. CAPITATA* MALES AND PARASITIDS

D. longicaudata was the parasitoid species chosen to attempt this two simultaneous productions at INTA Castelar. First the genetic sexing strain of *C. capitata* was evaluated as potential host for a mass rearing program of *D. longicaudata* (Viscarret et al. 2006). These authors compared the biological characteristics (preoviposition / oviposition periods, longevity, survival, fecundity, sex ratio) of two parasitoids strains, one rearing on wild-type *C. capitata*, and the other, rearing on the genetic sexing strain. The results indicate

that the parasitoid reared on the metabolically slower larvae of female of the fruit fly genetic sexing strain Cast191 reach the same biological quality as those on wild larvae (Viscarret et al 2006).

MASSIVE PRODUCTION

Then, the potential use of the Cast191 strain of *C. capitata* for producing sterile males and *D. longicaudata* parasitoids, at larger-than-previously scales, was evaluated by Lopez et al (2006). These authors showed that even under standard "factory" conditions, the rate of parasitism obtained was similar to the one found when parasitoids are exposed to wild strain. Interestingly, they found an F1 sex rate biased toward females (López et al., 2006).

INTEGRATION IN THE FIELD

Standardized protocols are essential to compare results for any type of experiment. However no field design or cage test procedure has so far been proposed for evaluating the integration of SIT with BC. Implementing an integrated SIT+BC strategy in the field is a enormously wide subject. In a quick overview of several possible scenarios and how to evaluate results, we may go from the "apparently" simplest proposal to more detailed ones. As we shall see, the feasibility of the proposed experiments goes the other way around.

THE SIMPLEST IDEA

The simplest idea would be this: just divide your experimental field in four blocks, keep one as control, and, in the other three, continuously release sterile flies, or parasitoids, or both. Then record the damage.

THE ISOLATION PROBLEM

As we cannot prevent the insects from moving from one block to the next, dividing a single field is the first "wrong" idea with this "simple" experiment. So, we need at least four orchards as similar and as isolated as possible. In order to solve this, instead of performing different treatment in separate localities we may try to work in confined environments, i.e. cages. Here, there are a number of thinkable sizes according to the type of observation and the expected results, as we shall consider later on.

GETTING ENOUGH REPETITIONS

The second problem with this apparently simple assay is reps: We need to repeat the experiment enough times to give the results any statistical significance, so either we have got sets of four orchards in several different places, or, we repeat the experiment many times on the same place. Cages may also be a solution for this problem. It is not unreasonable to think of a large number of cages, performing every treatment in each one of them. Meanwhile, nobody would dream of having access to four (let alone, N times four) orchards just to perform experiments.

THE TIME PROBLEM

The third objection is time: how long are we prepared to wait for results? Fruit yielding is a number obtained at the end of each season so, waiting for the damage on fruit to show up means, "one season - one rep". We may find a way around this by monitoring either the evolution along time of the presence of flies (trapping), or of the presence of larvae (opening fruits, or waiting for them to develop and then, counting pupae). A closer look at the action of the controlling agents would be gained

by: a) collecting wild flies' eggs and incubating them in a wet chamber, in order to record "hatching" as an indication of the action of sterile males, and b) collecting juveniles (larvae or egg), rearing them to adult, and recording the action of BC as % parasitism.

FIELD EXPERIMENTS

Out-in-the-field experiments cited by the literature offer examples of some of these different levels of complexity and progressive narrower – but more precise – expectations for the result of the assays.

OPEN FIELD

There is at least one experiment really performed in the open field by Wong et al. (1987, 1991, 1992) in the island of Maui, Hawaii. Here, the entire area (13 km²) was considered as just one block, SIT and BC were applied in different times. To put the results in numbers, SIT alone reduced 4.7 times the number of flies per kilo recovered, the parasitoid, *Diachasmimorpha tryoni*, used alone reduced 1.3 times that number, but the two acting together caused a reduction of 12.3 times.

LARGE FIELD CAGES

The next level would be the huge cages (230m³ used by Rendón et al. (2006)). This was a valuable and tremendous effort repeated at four different sites (varying in altitude and other environmental conditions), with eight cages each. Sterile males were of the TSL strain. Two parasitoids species were released simultaneously instead of one (but the egg parasitoid, *Fopius arisanus*, left too little to do to the larva parasitoid, *Diachasmimorpha krausii*). This work is a good example of the "how to measure" problem mentioned above.

Rendón et al. (2006) decided to pick up coffee berries at the end of the experiment, and after obtaining the pupae, compare the treatments in terms of number of pupae obtained per kilogram of fruit, but, they found that, in this experience, it was more meaningful to compare total numbers of adult flies (i.e. those escaping the control). The final result was that the combination of parasitoid and sterile flies resulted in increased effectiveness sometimes, but others did not. Neither parasitoids nor sterile males were equally effective in all temperatures and environments.

STANDARD-SIZE CAGES

Cage studies on lepidopteran pests have been reported indicating compatibility between the two control tactics (Bloem and Carpenter 2001), but for fruit flies no antecedent is registered so far in regular size cages. We intended this approach trying to follow the same cohort of flies, from egg to larvae (like Rendón et al did, in the huge cages mentioned above) but using 14m³ cages with small trees (*Citrus reticulata*) inside. The insects used were: *C. capitata* wild strain MI94, and *D. longicauda*, reared on the same fruit fly strain at INTA Castelar. Natural (peaches), as well as artificial (bags full of larva food) fruits were exposed to wild flies inside the cages with or without the presence of sterile male (X ray sterilized males from the genetic sexing strain CAST191). One week later, the same fruit were exposed to parasitoids released in the same cages. The fruits were then incubated and the emerged adults recorded. Every experiment lasted about 3 weeks and 9 repetitions were planned, though only 5 were actually performed. The cages were partially protected from the rain by a high roof, however the unusually bad weather and low temperatures of this season (spring 2005 in Castelar) prevented the insects from being active enough, along the entire period of time required. Even when this

experiment failed, we show here the actual results of repetition 5 (Figure 3), just to illustrate the expected outcome under the “no interference” assumption.

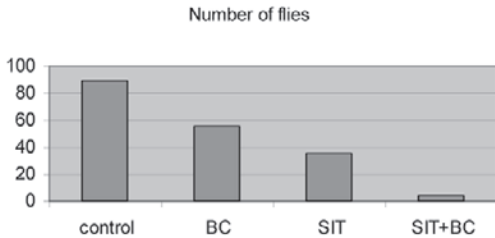


Figure 3. EXPECTED OUTCOME. Number of adults emerged from fruits exposed to different treatments

STANDARD CAGE, ATTEMPT TWO

A less ambitious experiment, only lasting two days was performed in similar 14 m³ caged trees. Wild flies and parasitoid were the same but the sterile males used were TSL from the ISCAMEN Insect Factory, in Mendoza. Artificial plastic fruits with a piece of polyurethane foam moistened in orange juice were used for the fruit flies to lay eggs. The substrate for the parasitoids to lay eggs was a voile bag with fresh diet and larvae inside. Five plastic fruit and 5 bags with food and larvae, were hanging from a piece of wire and removed as needed. The variables registered were: in the first case, % of hatching; and in the second, % of parasitism. The numbers of insects were, wild flies =50 males + 50 females; sterile males = 1250; parasitoids = 100 females + 50 males. The average number of eggs (laid by wild females and observed) per cage was 140 (range 50-315).

ADULT PERFORMANCES

The %hatching, of SIT and BC+SIT treatments resulted different from the CONTROL but not between them (CV= 2.570, alpha=0.2); and

the % parasitism was not different between BC and SIT + BC (CV = 3.345, $\alpha = 0.05$), while in the CONTROL it was zero (Table 1). Conclusion: the performance of the parasitoids and sterile males of fruit flies was not affected by the presence of the other species even in the artificially forced situation of a confined environment.

TABLE 1. ADULT PERFORMANCE. Performance of the parasitoids (% parasitism) and sterile males of fruit flies (% egg hatch) after different treatments

Field Cages (n=8)	Egg hatch		Parasitism	
	mean	Sd	mean	sd
control	46.9	7.8	0.0	0.0
SIT	25.6	8.6	-	-
BC	-	-	9.4	3.7
SIT+BC	32.1	7.4	9.5	3.0

LAB CAGES AND DIRECT INTERACTIONS

In the previous experiment only the results of the activity (performance) of both insects was measured. Direct interactions between them could still be occurring and not necessarily being reflected by their performances. Presently, another experiment is in progress using a more reduced scale: indoor cages (0.15 m³) with an artificial twig inside, kept in an isolated room, and using natural fruits (oranges) for egg laying activities. The numbers of insects are: wild = 70 M+70F, sterile male (Cast191) = 1750, parasitoids = 120 F + 60 M. The observations planned include not only the number of insects obtained, as previously, but also a close record of the number and the kind of “physical contact” or interactions between both insects.

EPILOGUE

The problem of controlling both *A. fraterculus* and *C. capitata* along the many different

geographical and ecological regions producing fruit in Argentina is a very complex one. The application of fruit fly management and eradication practices suitable to each particular situation but closely coordinated by the National Fruit Fly Control and Eradication Program (PROCEM) should certainly facilitate this task. *D. longicaudata* is currently reared, only on a small-scale, in two fruit fly Laboratories, at PROIMI, Tucumán, and at INTA-Castelar. There, detailed studies on bio-ecology of this bio-control agent are being conducted to determine its suitability for fruit fly control programs along the varied fruit producing regions in Argentina (Ovruski et al., 2003; Viscarret et al., 2006). At INTA-Castelar *D. longicaudata* is reared on larvae of a genetic sexing strain of *C. capitata*, in which the female larvae are waste product because only the males are used in the SIT. Comparative biological studies between *D. longicaudata* strains, reared on larvae of a genetic sexing and a wild strain of *C. capitata* have been completed. Moreover, this parasitoid now reared on *A. fraterculus* larvae, is currently being evaluated, and preliminary results are very encouraging (see A. Soria et al., this Meeting). Studies like this, will be basic for mass production and future releases of this parasitoid in the Northwestern provinces of San Juan and La Rioja, and in the most extreme Northeastern province of Misiones, all of them in Argentina. From an ecological point of view the combination of rearing and releasing sterile insect and parasitoid in this country, albeit properly integrated, could be a most effective and practical alternative for controlling fruit flies in Argentina.

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