Project Title: Management of Spotted Wing Drosophila in the lower San Joaquin Valley

Principal Investigators

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Objectives of Proposed Research (Year 1 of 3)

Improve Management of Spotted Wing Drosophila (SWD) in the lower San Joaquin Valley by

1) Determining seasonal patterns in adult SWD activity
2) Evaluating the phenology of fly movement between overwintering hosts and cherries
3) Conducting an exploratory survey for parasitoids of drosophilans in the lower San Joaquin Valley.

Justification and Importance of Proposed Research

Spotted wing drosophila (SWD) is a significant new pest of cherries throughout the western United States. Since 2008 damage from this pest, coupled with added expenses for management programs, have resulted in significant economic losses to cherry growers throughout California.

Due to the significance of this pest several researchers have begun studies that will lead to sustainable management programs for cherry growers. These researchers have made significant progress on several aspects of integrated pest management programs such as trapping, defining relative susceptibilities of different crop stages, evaluating chemical controls, and determining developmental fly biology. The purpose of this project is to fill some of the current voids in this research as they pertain to understanding the field biology and phenology of SWD, particularly in the lower San Joaquin Valley.

Experimental Procedures to Accomplish Objectives

1) Determine seasonal patterns in adult SWD activity in the lower San Joaquin Valley.

During 2013 we conducted our third and final year of a SWD trapping program in citrus, cherries and blueberries in the General Beale and Edison regions of Kern County. During this final year we did weekly monitoring of 22 traps in 11 different citrus or cherry orchards from 17 Oct 2012 to 18 Jun 2013. In each orchard we placed two bucket traps on opposite ends of the orchard. The trap consists of a 26 fl oz. plastic container with a transparent lid with a 3.1 inch diameter opening on the lid covered with 1/8 inch hardware cloth. Each trap was baited with approximately 5 fl oz of apple cider vinegar and hung from a tree scaffold approximately four feet from the ground. On a weekly basis traps were collected, returned to the laboratory and

evaluated for the number of male and female spotted wing drosophila. Data were analyzed by plotting trends in trap catches over time in a chart to visualize changes in pest density throughout the trapping period.

From fall 2010 to June 2012 we determined that spotted wing drosophila has two main periods of activity in cherries. The first period is in the fall from October to December and the second period is from April through mid-June. In citrus there was just one prolonged period of activity that started in October and continued through April. During the final year of trapping in 2013 data from all commodities were pooled together and a similar trend was seen as in previous years whereby adult fly activity began in late October, increased through December, maintained itself through late winter and early spring, and then decreased in late April (Fig.1). However, it is important to note that all monitoring sites were within commercial orchards and received insecticide treatments for SWD (cherries in April) or for glassy winged sharpshooter and citrus thrips (citrus in April). Therefore it is logical to interpret that the reductions in April were due to pesticide applications across all of our trapping locations, and not because of environmental conditions. In previous years of data we showed that if spotted wing drosophila is not sprayed, it survives very well through May and into June, and by the first week in July environmental conditions are too hot and dry for adult flies to be active.

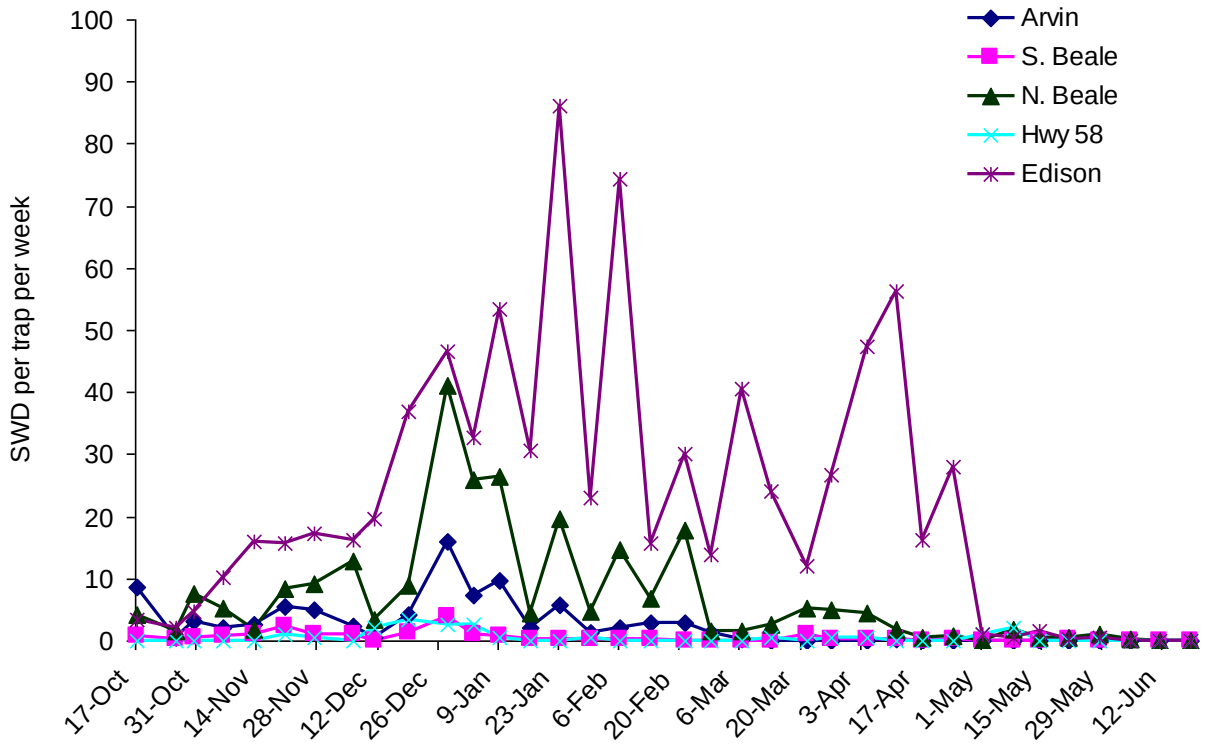

Fig. 1. Average spotted wing drosophila adults collected from 22 bucket traps placed in 11 citrus and cherry orchards placed in the Arvin, General Beale and Edison regions of Kern County from October 2012 to June 2013.

2) Evaluate the phenology of fly movement between overwintering hosts and cherries
Kern County offers a unique opportunity to research the regional movement of SWD among crops due to the presence of a known overwintering host for SWD (citrus) immediately next to cherries. This allows us to do transect studies to evaluate fly behavior with regards to movement from one crop to the other. During the past two years we have conducted transect studies extending 1/10 of a mile into citrus and 1/10 of a mile into cherries. Studies have allowed us to learn that flies are almost exclusively in citrus prior to 5 weeks to harvest, that fly movement to cherries begins 3-5 weeks prior to harvest of cherries, and that the first flies to migrate to cherries are predominantly female. This has led to recommendations regarding the use of trapping and guidelines for how to interpret the results of trap catches as they relate to management programs.

During 2013 we collected our final set of transect data. Two transects of bucket traps (18 traps per transect) were placed in a line perpendicular to the interface between citrus and cherries. Traps were placed at 85 foot (5 row) intervals to 510 feet (.08 mile) into the citrus orchard and 1105 feet (0.21 mile) into the cherry orchard. If the transect had been extended in the citrus it would have continued into more citrus; if the transect had been extended in the cherries it would have gone into several miles of rangeland. Traps were placed into the field on 20 Feb and were evaluated weekly for the number of adult SWD males and females through 14 May.

During the first four weeks of evaluation (20 Feb to 21 Mar) SWD adults were almost exclusively in the citrus (Fig. 2a). During this period of time the ten traps in citrus averaged 43 SWD per trap per week whereas the 26 traps in cherries averaged 0.5 SWD per trap per week.

Approximately five weeks prior to harvest SWD began migrating into the cherries (Fig. 2b). During the three weeks from 21 Mar to 11 Apr the average number of flies in citrus was 27 per trap per week compared to 30 per trap per week in the cherries. Further analysis of the cherry data shows an edge effect whereby traps that were within 510 feet of citrus (= 30 rows of trees at 17' spacing) averaged 48 SWD per trap per week compared to 14 SWD per trap per week in traps greater than 510 ft from the citrus-cherry interface. Analysis of data from week to week on 21 Mar, 27 Mar, 4 Apr and 11 Apr showed that almost no flies were present in the cherries prior to 21 Mar, that they had moved approximately 600ft into the cherries by 27 Mar, approximately 900 feet into the orchard by 4 Apr, and throughout the full 1105 feet of the orchard by 11 Apr.

Approximately three weeks until harvest the cooperating cherry grower began a weekly insecticide treatment program to control SWD prior to harvest (Warrior, followed by Delegate, followed by Malathion). As a result, the number of SWD in the cherry orchard became significantly reduced during the three weeks prior to harvest (Fig. 2c). Additionally, around the 20th of April the citrus orchard was sprayed with Danitol as part of a USDA areawide treatment program targeting glassy-winged sharpshooter. As a result of these treatments there were almost no SWD collected in either the citrus or the cherries during the 3-week harvest period from 23 Apr to 14 May (Fig. 2d).

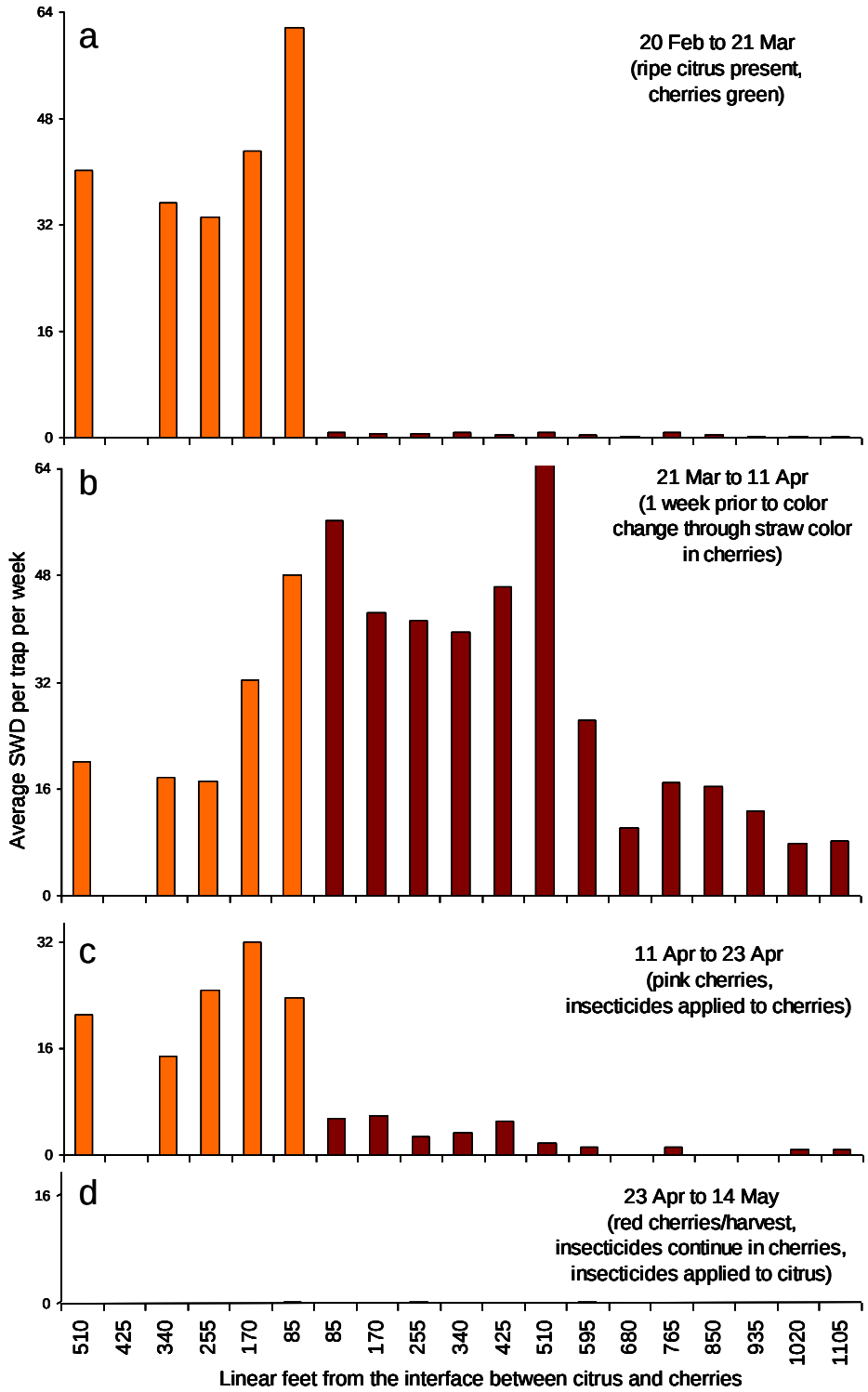

Fig. 2. Captures of SWD in a transect of bucket traps placed perpendicular to the interface between citrus and citrus orchards during four time periods prior to cherry harvest. Data show a) that SWD is primarily in citrus while cherry fruit are green from 20 Feb to 21 Mar, b) that SWD moves to cherries during the period of early color development in late March to early April, c) SWD populations once insecticide treatments begin in cherries, and d) SWD populations when insecticide treatments when both cherries and citrus have been treated with insecticides.

Gender-biased movement
One of the purposes of SWD traps is to monitor prior to harvest to determine the need for treatment. However, data collected in 2013 corroborates previous concerns from our research in 2011 and 2012 that this may be difficult due to a gender bias in SWD captures in cherries.

Analysis of data from evaluation dates of 6 Mar, 14 Mar, 21 Mar and 27 Mar during the period of time of early migrating of SWD into the cherry orchards shows that the SWD population is approximately 50% male and 50% female in the citrus (Fig. 3a). However, the initial invasion of SWD into cherries is primarily done by females (Fig. 2b). In total the 26 SWD traps in cherries evaluated from 6 Mar to 21 Mar captured 45 SWD, of which only 6 (13.3%) were males. This means that 87% of the SWD population, comprised of the part of the population that damages the crop, is going undetected during this period of time. This can easily lead growers and pest control advisors to a false conclusion that SWD is not present in the orchard at the same time as female SWD have begun to sting fruit and damage the cherry crop. It is also important to remember that during the same three-week period of time that 26 SWD traps in the cherries only caught 6 males, a set of 10 SWD traps in the adjacent citrus caught a total of 560 SWD. This means that a cherry grower or PCA, if only using traps in their cherry orchard, and only evaluating traps for drosophila with spots on their wings (males), is likely to be completely oblivious to the SWD threat that has built up in the neighboring citrus orchard, and is likely going to be unable to detect the presence of SWD in his or her own orchard until after damage has already begun to occur.

3) Conduct an exploratory survey for parasitoids of drosophilans in the lower San Joaquin Valley.
Biological control of spotted wing drosophila is a topic that has not been widely explored in California. However, it is relatively safe to assume that biological control organisms are already present in California due to the long-time presence of other drosophila species. During 2013 we did some exploratory work to determine which species of parasitoids were already present in California, and to determine if they could attack SWD.

During 2013 we conducted field evaluations for SWD parasitoids in the spring (completed) and the fall (in progress from Oct-Dec 2013). For the spring surveys we placed five sentinel traps underneath random citrus trees in each of two citrus orchards from Feb through May. Each trap consisted of a 591 ml flat-bottomed square plastic container with a snap-on lid. Approximately 200 ml of artificial drosophila diet (Jazz-mix drosophila diet, Fischer Scientific) was placed into the bottom of each container and allowed to cool. After cooling, a total of 40 mixed gender adult SWD were put into each container for a period of 12 days to lay eggs. Eggs were allowed to hatch and grow under ambient conditions on an indoor laboratory countertop. After the 12 days the lid was removed and the traps were placed in the orchard. At this time traps had mixed-stage SWD maggots and new pupae. Traps were left in the field for 7 days, at which time they were collected and stored in the laboratory for a period of 5 weeks with the lid replaced. It was determined that a period of 5 weeks was long enough for all parasitoids to emerge, but not long enough for a second generation of parasitism to occur. At the end of 5 weeks each trap was opened and adult parasitoids were counted and identified.

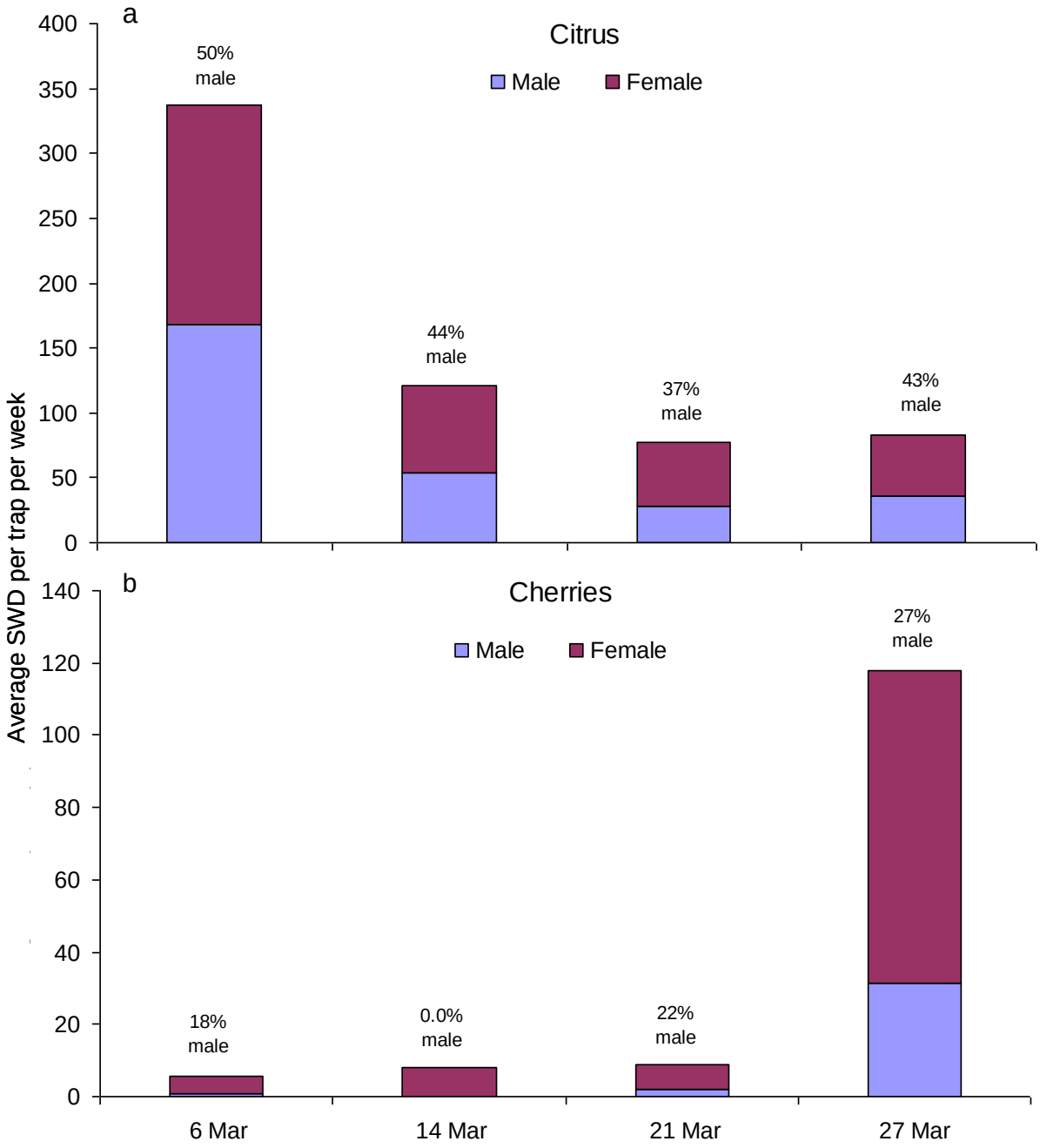

Fig 3. Male to female ratios of SWD collected in a) citrus and b) cherries from late February through late March during the period of time that SWD begins migrating from citrus to cherries. During this period of time growers and pest control advisors often monitor for SWD to determine the need for treatment. Data show that counting only males during the period of early migration could lead to false negatives (thinking SWD is absent when really it is present).

Sentinel traps were evaluated weekly for 12 weeks from Feb through May, with a three-week gap from mid-April to early May (Fig. 4). In total we collected 1,671 parasitoids, of which 100% were in the genus *Pachycrepoideus*, likely *P. vindemmiae* (Rondani). This species is known as an ectoparasitic idiobiont parasitoid that attacks puparia of many different groups of flies, including drosophilans, as well as insects in several other insect orders. During the first three weeks of evaluation prior to 27 Feb we collected very few parasitoids. Most of the parasitoids were collected from early March to early May. Parasitoid captures decreased again during the last two weeks of May, though we are uncertain if this was due to decreases in the density of SWD hosts, parasitoid biology, pesticide use, or due to hotter climatic conditions that caused the artificial diet in our sentinel traps to dry up and become unsuitable for SWD. It is probably that all four factors played a role in the decrease.

After parasitoid emergence we collected live parasitoids from sentinel cages and placed them in a pure colony of SWD to confirm host status. Parasitoids were able to oviposit on SWD and consistently completed their life cycles under colony conditions. Once parastioid colonies were established they were provided to the laboratory of Dr. Kent Daane for future studies.

Fall surveys were completed from October through December. At the time of writing this report the data are still being collected. At this time parasitoids have emerged from the earliest weeks of trapping, other traps are in the lab while we wait for parasitoids to emerge, and the last traps are being prepared to be put into the field. Results from the fall trapping will be available in the first quarter of 2014 during the last three months of the 2013-14 funding cycle of this project.

Data from this project suggest that parasitism can play a role in the management of SWD on a landscape scale in alternate hosts like citrus. However, the biological profile of these parasitoids that states that they parasitize pupae of SWD suggests that they are unlikely to play a major role in biological control in cherries. For example, under Kern County conditions SWD adults migrate into cherries about five weeks prior to harvest, but parasitism could only occur after flies have already laid eggs, larvae have hatched, developed within fruit, and exited the fruit to pupate, at which time parasitism could occur. For this reason it is unlikely that this parasitoid will have practical value each spring within cherry orchards prior to harvest, but may have long-term benefits on a landscape scale at different times of the year.

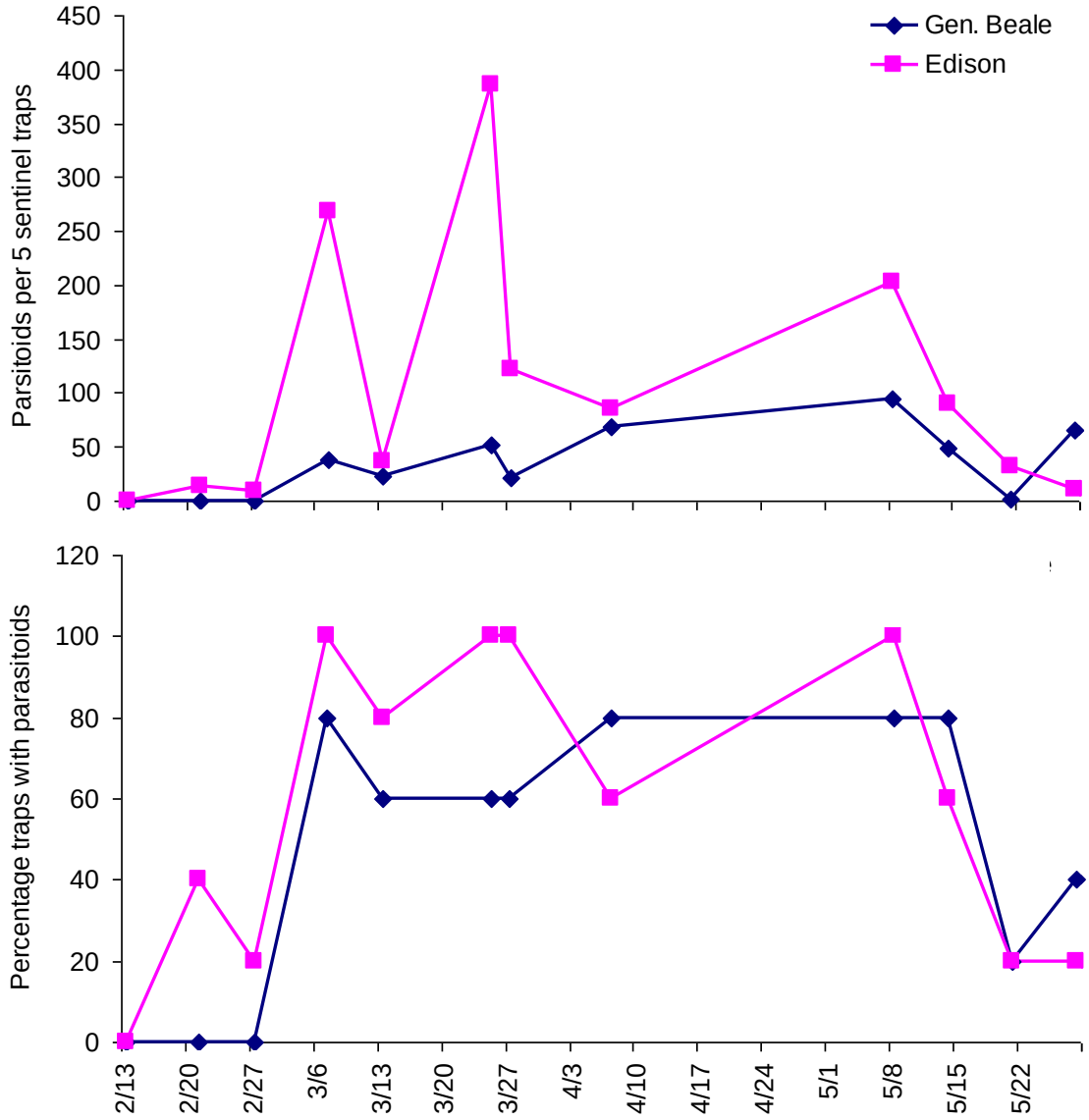

Fig. 4. Collections of the parasitoid Pachycrepoideus vindemmiae (Rondani) using sentinel traps in two citrus orchards in Kern County showing a) the total number of flies collected and b) the percentage of traps containing parasitoids.