Entomophaga, 27 (3), 1982, 301 à 310

EVALUATION OF *STETHORUS NIGRIPES [COL. : COCCINELLIDAE]* FOR BIOLOGICAL CONTROL OF SPIDER MITES IN CALIFORNIA ALMOND ORCHARDS

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Stethorus nigripes KAPUR (= *S. loxtoni* BRITTON & LEE) was imported from Australia in 1978 and released in California during 1978-1980. Laboratory and field cage studies evaluated aspects of *S. nigripes'* biology considered likely to affect establishment. Our tests indicated that most ♀♀became nonreproductive during late fall. The females' reproductive arrest seems not to be a true diapause, but may be due to chill experienced by pupae. Survival over winter of both sexes was low if they were not provided abundant prey ; honey or water alone were inadequate. *S. nigripes* adults and larvae could not feed on *Panonychus ulmi* (KOCH) or *P. citri* (MCGREGOR) eggs and avoided all stadia of *Bryobia rubrioculus* (SCHEUTEN) in laboratory tests, so it is not a "generalist" predator of spider mites. *S. nigripes* also is susceptible to pesticides used to control key insect pests in almonds, including the pyrethroid, permethrin (LC 50 value = 0.48 g A.I./100 liter water). Releases to establish this predator were discontinued after 3 years, as *S. nigripes'* sensitivity to pesticides and its requirement for prey during winter seem sufficient to account for its failure to establish. Even if established, these factors might prevent *S. nigripes* from becoming an effective spider mite predator in pesticide-treated almond orchards in California.

All known *Stethorus* species are predators of spider mites (MCMURTRY *et al.*, 1970) and several species have been demonstrated to be efficient biological control agents of spider mites in agricultural crops (for example, FIELD, 1979 ; HULL *et al.*, 1976 ; MCMURTRY & JOHNSON, 1966 ; READSHAW, 1975). While the phytoseiid predator *Metaseiulus (= Typhlodromus) occidentalis* (NESBITT) can control spider mites in some California almond orchards (HOY *et al.*, 1979), the addition of a predator that could move rapidly to spider mite "hot spots" would be useful, especially if it were an effective predator of the European red mite, *Panonychus ulmi* (KOCH), the citrus red mite, *P. citri* (MCGREGOR), and the brown mite, *Bryobia rubrioculus* (SCHEUTEN), as *M. occidentalis* is less effective against these prey (HOY *et al.*, 1979 ; HOY & SMILANICK, 1981).

S. nigripes was first imported from Australia in 1974 and released in California by the University of California Division of Biological Control, Albany under the name *S. loxtoni* BRITTON & LEE (RICHARDSON, 1977). *S. loxtoni* was synonomized recently with *S. nigripes* KAPUR (HOUSTON, 1980). About 300 and 19,000 *S. nigripes* were released in California in 1974 and 1976, respectively (RICHARDSON, 1977). No evidence

of permanent establishment was obtained but the impact of this species in Australian apple and peach orchards (RICHARDSON, 1977 ; FIELD, 1979 ; READSHAW, 1975) suggested that additional importation, evaluation, and releases were justified.

Biological control workers have been concerned with reasons for failure to establish exotic species in new environments and with strategies for increasing the rate of establishment (for example, DEBACH, 1965 ; HALL & EHLER, 1979 ; HOY, 1976 ; HUFFAKER & HOY, in prep. ; LUCAS, 1969 ; MESSENGER & VAN DEN BOSCH, 1971). We studied aspects of *S. nigripes'* biology and ecology that we believed might be critical to its successful establishment in California. For example, although RICHARDSON (1977) found no evidence for a hibernal diapause in *S. nigripes,* his colony could have been selected inadvertently for nondiapause (RICHARDSON, pers. comm.). We therefore obtained a new colony and tested it for its ability to diapause and overwinter under California conditions in the field and laboratory. Pesticide susceptibility was considered a possible barrier to establishment in commercial almond orchards ; *S. nigripes'* susceptibility to the synthetic pyrethroid, permethrin, was thus evaluated. *S. nigripes'* ability to survive winter conditions with and without prey or alternate foods, and the results of releases of this newly-imported colony of *S. nigripes* are reported.

MATERIALS AND METHODS

COLONY SOURCE AND MAINTENANCE

S. nigripes was collected on February 14 and 28, 1978 in Waikerie, South Australia by N.L. RICHARDSON. Two experimental colonies were begun in early March 1978 from about 230 progeny of the adults received by the quarantine facility. Most were used to initiate a laboratory colony that was reared at 20-27° C under a 16-h daylength. The remainder (ca. 50) initiated an outdoor colony that was kept continuously in a field cage in Berkeley, California (CA) to minimize inadvertent selection against diapause. *Tetranychus urticae* (KOCH) on blackeyed pea leaves *(Vigna unguiculata unguiculata)* were provided as prey. Both colonies were kept in 0.47 liter unwaxed paper containers.

DEVELOPMENT AND OVIPOSITION UNDER A CONSTANT SHORT DAY AT 19° C

S. nigripes from the laboratory colony were reared at 19° C under a 10-h daylength. About 100 ♀♀ were placed into 0.47 liter unwaxed cardboard containers for 3 days to oviposit and then removed. The 1st generation was reared with abundant *T. urticae* prey and the adults were left together for 1 week for mating and the pre-oviposition period. Each adult was then isolated in a plastic Petri dish (50 × 9 mm) for 1 week with a blackeyed pea leaf infested with *T. urticae* ; the number that deposited at least 1 egg was recorded. Since living ♂♂ are morphologically indistinguishable from ♀♀ (BRITTON & LEE, 1972 ; RICHARDSON, 1977), 50 % oviposition was interpreted to mean that all ♀♀ were ovipositing if there were a 1.1 sex ratio.

Dissections of nonovipositing beetles were conducted to confirm this assumption. A 2nd generation of beetles was reared under the same conditions and tested in the same way to determine if diapause might have been induced in the maternal generation.

OVIPOSITION AND DEVELOPMENT UNDER CYCLIC TEMPERATURES AND VARYING DAYLENGTHS

The population of beetles reared continuously in the Berkeley field cage since March 1978 was tested every month from September 1978 to March 1979 to determine

their reproductive status. Eighty adults were isolated each month with abundant *T. urticae* prey and held for 1 week in the field cage to determine the number that deposited at least 1 egg. Beetles tested outside between November 30 - December 7 were subsequently held with abundant prey at 22-24° C under a 16-h daylength for 1 week to determine if they would oviposit. In addition, on December 13 and January 7, 50 beetles were removed from the field cage and held for 1 week at 19° C under a 10-h daylength with abundant prey to determine the number that oviposited. On April 20 and May 7, 50 adults of unknown age were removed from the field cage and placed into a growth chamber with an 18-h daylength but with cyclic cool temperatures (table 2, December 1) for 2 weeks ; the number of ♀♀ovipositing during the 2nd week was recorded. On May 7 and 14, pupae from the field cage were placed into a growth chamber under an 18-h daylength and cyclic cool temperatures (table 2, December 1). The resultant adults, 8-11 days old, were held 1 week to determine if oviposition occurred. A hygrothermograph in a standard weather shelter recorded temperatures during the course of the field cage tests in Berkeley, CA (table 1).

TABLE 1

Temperature conditions (° C) recorded in a field cage at Berkeley, CA, 1978-1979 during oviposition tests with S. nigripes

Test Date	Mean	Maximum	Minimum
Sept. 6-12	23	37	14
Sept. 30 - Oct. 2	20	31	13
Oct. 31 - Nov. 7	15	26	9
Nov. 30 - Dec. 7	9	15	1
Jan. 6-13	11	13	7
Feb. 5-13	12	18	6
Mar. 2-9	14	23	6

TABLE 2

Temperatures and daylengths used for growth chamber tests with S. nigripes

Temperatures (° C)				Daylength	
Simulated date	Minimum	Mean	Maximum	Simulated date	Photophase
Aug. 30	14.4	24.0	35.0	Aug. 30	13:00
Sept. 16	9.5	18.9	31.1	Sept. 6	12:45
Oct. 1	8.3	17.3	29.4	Sept. 14	12:30
Oct. 17	5.0	13.9	26.1	Sept. 20	12:15
Nov. 1	4.4	10.8	25.0	Sept. 26	12:00
Nov. 16	2.8	8.3	17.2	Oct. 2	11:45
Dec. 1	0.6	4.5	16.1	Oct. 10	11:30
Dec. 17	0.0	6.3	17.2	Oct. 17	11:15
Jan. 1	2.2	6.9	14.4	Oct. 24	11:00
Jan. 17	3.3	9.3	16.1	Oct. 31	10:45
Feb. 1	5.0	9.2	17.8	Nov. 7	10:30
Feb. 15	6.7	12.9	21.7	Nov. 15	10:15
				Nov. 26	10:00
				Dec. 13	9:45
				Jan. 17	10:00
				Jan. 26	10:15
				Feb. 3	10:30
				Feb. 18	10:45

Weather conditions are more extreme in the San Joaquin Valley of CA than in Berkeley, so we also tested beetles under simulated conditions (table 2). Temperatures in a growth chamber (Percival Mfg., Model E-30B) were controlled by plastic cams cut so that temperatures cycled daily between maximum and minimum values calculated by averaging 3 years of temperature data from the Kearney Horticultural Field Station (KHFS) at Parlier, CA. The shape of the curves mimicked that of the KHFS weather data. Maximum and minimum values were changed twice a month by replacing the plastic cams. Lighting was provided by 20-w cool white fluorescent bulbs and daylength was decreased or increased by 15 mn intervals on appropriate dates (table 2). The beetles always were given excess *T. urticae* prey of all stages. On Aug. 30 (simulated date), 500 adults were allowed to oviposit for 40 h on blackeyed pea leaves infested with *T. urticae.* The resulting 200-300 eggs were labeled the F_1 generation. When the F_1 beetles completed development in the 3rd week of September, they were allowed to mate and oviposit. Each month a different group of 60 F_1 adults was isolated, and the number of beetles that deposited 1 or more eggs within a week was recorded until the experiment was terminated in February. The F_1 beetles were transferred to new cartons every 2-3 weeks and their mortality was estimated then. The F_2 generation was reared similarly and the 1st individuals completed development by the last week of October ; the number of F_2 females that oviposited within a 1 week interval was determined as for the F_1 generation. Only 23 F_3 beetles from eggs deposited in late October completed development by the end of February. These F_3 adults were held a week to determine if they would oviposit.

ALTERNATE FOODS

Since the beetles in the 2 previous experiments were always provided with excess *T. urticae* prey we also determined the effects of reduced or alternate foods on adult longevity over winter. Adult beetles provided low prey do not oviposit ; therefore fecundity could not be evaluated. Beetles were reared from egg to adulthood under growth chamber conditions approximating the late November temperatures and daylengths in the San Joaquin Valley (table 2). At maturity, they were isolated in Petri dishes. One group (31 beetles) was given no food or water ; 25 were given water only on a small wad of cotton ; 24 were given diluted honey on filter paper. Nine control adults were fed excess *T. urticae.* Mortality was assessed every 1-2 days.

FEEDING SUCCESS WITH SPIDER MITES

S. nigripes adults and larvae were starved 24 h and placed on leaf discs with all stages of either *P. citri, P. ulmi,* or *B. rubrioculus,* which were confined to the disc by a water moat. Beetles (10-20 each) were observed up to 55 mn and their feeding success was recorded.

PESTICIDE TEST

Successful establishment and persistence of *S. nigripes* in commercial almond orchards would be enhanced if the predator exhibited tolerance to insecticides used to control key insect pests. Because permethrin was recently registered for use in California almond orchards, its effect on *S. nigripes* adults was assessed using groups of 20 adults which were confined on filter paper in a covered 9 × 50 mm Petri dish. The filter paper was dipped in an aqueous pesticide solution (Permethrin 2 EC) and allowed to dry before the beetles were placed on it. Mortality was recorded after 48 h,

using 0.1, 0.5, 0.75, 1.0, 1.5, and 2.0 g AI/100 liter water. Other insecticides commonly used in California almonds were tested by WALTERS (1976) and thus were not tested by us.

RELEASES OF *S. NIGRIPES*

Adult beetles were released at 16 sites in the San Joaquin Valley of CA during June through August in 1978-1980. Release numbers ranged from 150 to 1400, averaging 500/release. Approximately 12,000 beetles were released over the 3 year period : 11 releases were made in almond orchards ; 2 in peaches ; 2 in alfalfa ; and 1 in a poplar grove. All sites had abundant spider mites present, with *T. urticae* or *T. pacificus* predominating. Sites were selected because they were in an experimental check block or were otherwise unlikely to be treated with pesticides. One release into alfalfa was made into 3 field cages in May when abundant spider mites were present ; spider mites were present through the winter on the uncut alfalfa so overwintering success was monitored closely.

RESULTS AND DISCUSSION

DEVELOPMENT AND OVIPOSITION UNDER CONSTANT SHORT DAY AT 19° C

No obligate diapause was found in this colony of *S. nigripes* which has been held under natural daylength conditions until these tests in order to prevent inadvertent selection against diapause. Of 178 *S. nigripes* reared from egg to adulthood at a constant 19° C under a 10-h day, 62 oviposited (35 %). Dissection of 102 of these beetles indicated that 39 % were ♀♀ , a skew from the normal 1:1 sex ratio

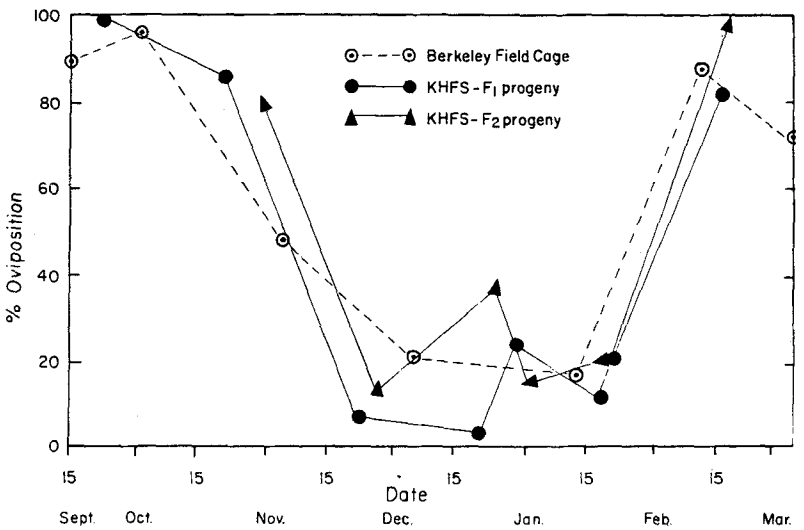

FIG. 1. The proportion of *S. nigripes* females ovipositing in conditions of variable daylength and cyclic temperatures in the Berkeley field cage and in the growth chamber mimicking San Joaquin Valley conditions (KHFS - F_1 and F_2 progeny). See tables 1 and 2 for details of temperature and daylength conditions.

(RICHARDSON, 1977). Thus, most of the F_1 ♀♀ were reproductively active. Their progeny were reared under the same conditions and most ♀♀ also oviposited (37 %) ; 43 % of the F_2 beetles were ♀♀. Development to adulthood required ça. 5 weeks at 19° C indicating that no adult, larval, or pupal diapause occurred during these 2 generations. As RICHARDSON (1977) did not evaluate diapause induction in an F_2 generation in the colony he tested, this is the first evidence for lack of a maternal influence on diapause induction in *S. nigripes*.

OVIPOSITION AND DEVELOPMENT UNDER CYCLIC TEMPERATURES AND VARYING DAYLENGTHS

Reproduction in *S. nigripes* ♀♀ was arrested when beetles were reared under decreasing daylengths and cyclic cool temperatures in both the field cage and growth chamber tests. *S. nigripes* reared with abundant *T. urticae* prey in field cages at Berkeley, CA oviposited in September, but by late October only 24 of the 58 ♀♀ (41 %) tested oviposited (fig. 1). Only 7 of 33 ♀♀ (21 %) tested in the field cage during the November 30 - December 7 interval oviposited, and 6 of 35 (17 %) ♀♀ oviposited in the January interval. By February 5, 36 of 41 (88 %) ♀♀ oviposited under increasing temperatures and lengthening daylengths and on March 9, 26 of 37 (70 %) ♀♀ oviposited. Thus, oviposition was arrested in the majority of *S. nigripes* ♀♀ tested during November, December, and January in the Berkeley field cages, even though abundant food was present. Most *S. nigripes* ♀♀ reared under the growth chamber conditions mimicking the KHFS late fall temperatures and daylengths also failed to oviposit. Few ♀♀ oviposited in the November, December, or January assays but most ♀♀ tested in February oviposited (F_1 and F_2 KHFS progeny, fig. 1). Survival in the growth chamber of the F_1 and F_2 beetles (always provided abundant prey) was high. Mortality of the F_1 beetles (held from October 28 until February 17) was ca. 12 %, while mortality of F_2 beetles (held from November 18 until February 13) was ca. 13 %.

The discrepancy between the results obtained when beetles were reared at a constant 19° C under a 10-h daylength (active oviposition) vs. those obtained under cyclic cool, short daylengths (reproductive arrest) is interesting. To learn if the reproductive arrest is a diapause inducible by the cyclic outdoor conditions, but not by a constant 19° C and 10-h daylength, we moved beetles from the field cage to various conditions. We assumed that rapid termination (in a week or less) of the reproductive arrest would be diagnostic of a dormancy induced "as a direct response to deleterious physical forces" rather than a diapause which "may not be terminated until long after the disappearance of such conditions" (BECK, 1968). Thirteen of 40 beetles tested outdoors November 7-14 oviposited within 1 week in the field cage. When the nonovipositing beetles were held at 22-24° C under a 16-h daylength, 6 more oviposited within 1 week, indicating a normal sex ratio and rapid oviposition in this sample. Of 80 beetles tested in the field cage during November 30 - December 7, only 7 oviposited outdoors and 8 were dead or missing. The remainder (65) were placed at 22-24° C under 16-h daylength, and 22 of 65 oviposited within 1 week ; when the 41 nonovipositing beetles were dissected, only 4 were ♀♀. Thus, ♀♀ oviposited rapidly upon transfer to a long daylength and warm temperatures. On December 13, 50 beetles were removed from the field cage and placed at 19° C under a 10-h daylength, conditions believed unlikely to terminate a diapause. Twenty beetles oviposited within 1 week ; 27 nonovipositing beetles were dissected and only 3 were ♀♀. Similar results were obtained when 50 beetles were tested at 19° C under a 10-h daylength on January 7 ; 20 oviposited within 1 week and only 3 of the nonovipositing beetles were . Thus, we conclude the failure to oviposit outdoors (or in the KHFS growth chamber) during the November, December, and January period was probably due to

the low temperatures (and perhaps declining daylengths) in the field cage during this period.

To discriminate between the influence of temperature and daylength, 49 beetles of unknown age were removed from the field cage on April 30 (when they were ovipositing) and placed into a long day (18-h) but cool temperatures (table 2, December 1). However, 11 of the 14 ♀♀ tested oviposited within 1 week, which seemed to refute our hypothesis regarding the effect of cool temperatures on oviposition. Similar results were obtained when 49 adults of unknown age were placed in to the same conditions from the field cage on May 7. Seventeen beetles were ♀♀ and 15 oviposited within a week ; furthermore, they continued to oviposit through a 2nd week of testing. The results suggest that these cool temperatures per se do not prevent adult *S. nigripes* from ovipositing. The situation seemed to be clarified when pupae were tested. Pupae removed from the field cage in early May were placed into an 18-h daylength but cool, cyclic temperatures (table 2, December 1). None of the presumably-mated adults 8-11 days old oviposited within 1 week and 17 of 32 beetles were ♀♀. Repetition with 14 beetle pupae yielded similar results ; all (7) adult ♀♀ failed to oviposit. Thus, *S. nigripes* pupae are sensitive to these cool cyclic temperatures and the resultant adults are in a dormancy which can be terminated rapidly upon transfer to warmer conditions (22-24, or 19° C). The effect of these cool conditions on ♂ ♂ was not evaluated.

RICHARDSON (1977) and FIELD (1977) reported that *S. nigripes* eggs, larvae, and adults could be found associated with hibernating *T. urticae* in tree bands throughout the winter in Australia and concluded on that basis that there was no obligatory diapause. We confirm their conclusion. However, we found *S. nigripes* reared in cool, cyclic temperatures and decreasing daylengths failed to oviposit in the growth chamber test or in the Berkeley field cage and showed that *S. nigripes* ♀♀ have a reproductive dormancy that can be triggered by exposure to these conditions during the pupal stage.

ALTERNATE FOODS

When adult beetles held under the fall-winter KHFS conditions were given nothing, water only, or honey in water, their survival rate declined substantially. Beetles given nothing lived 10.8 days (S.D. = 3.6) and beetles provided water only lived 10.1 days (S.D. = 4.6). Beetles provided honey lived 20.7 days (S.D. = 11.5), which is a significant improvement, but substantially less than for beetles provided prey. Mortality of *T. urticae*-fed beetles in the KHFS growth chamber conditions was ca. 12 % over ca. 100 days. It thus appears that *S. nigripes* adults require prey during the winter despite the reproductive dormancy the ♀♀ exhibit. PUTMAN (1955) found that *S. punctillum* WEISE behaved similarly with these alternate foods in Canada.

FEEDING SUCCESS WITH SPIDER MITES

Starved *S. nigripes* adults and larvae were never observed feeding on any stages of *B. rubrioculus* in the laboratory. Adult and immature stages of *S. nigripes* fed only on the mobile stages of *P. ulmi* and *P. citri* and appeared unable to feed on *Panonychus* spp. eggs. Apparently they were unable to penetrate the egg chorions. *P. ulmi* overwinter as diapausing eggs on almond twigs, so would not be "available" as prey for *S. nigripes* unless the egg chorions were damaged. Eggs and all other stadia of *T. urticae* were consumed readily ; *T. urticae* and *T. pacificus* ♀♀ overwinter in diapause in bark crevices and in litter and could serve as prey although their abundance overwinter might be limited. While *S. nigripes* appears to be a potential predator of *Tetranychus* spp., it seems unlikely that *S. nigripes* would be a dominant biological

control agent of *B. rubrioculus, P. ulmi* or *P. citri* in CA almond orchards because of its failure to feed on all stadia.

PESTICIDE TEST

Permethrin was very toxic to adult *S. nigripes*. An LC_{50} of 0.48 g AI/100 liter water (95 % C.I. = 0.29-0.79) indicates that no survival would be expected under field conditions. WALTERS (1976) demonstrated that *S. nigripes* is susceptible to azinphosmethyl and carbaryl, insecticides commonly used to control insect pests in CA almond orchards. Thus, the insecticides currently used in almond pest management would be disruptive to the establishment or efficacy of *S. nigripes* in CA.

RELEASE OF *S. NIGRIPES*

In 1978, a few (less than 5) beetles were recovered in 4 of the 7 release sites. At 3 sites, only 1 recovery was made. At the most promising site (where the spider mite population was sustained for the entire summer), a few beetles were recovered on 5 dates up to 2 months after release in an unsprayed peach orchard. Even here *S. nigripes* did not obviously multiply and none were found the following spring. In 1979, a few *S. nigripes* were recovered once only in 3 of the 6 release sites and no evidence of establishment was obtained. No recoveries were made in the 3 field cages in the alfalfa field at the KHFS despite the presence of prey over the winter and freedom from pesticides. During 1980, no recoveries were made. It is possible that *S. nigripes* has become established in CA, but is present in very low numbers in untreated refuges.

Our tests were designed to answer questions about *S. nigripes'* biology, feeding behavior, and response to pesticides so that establishment releases could be made more effectively. Because *S. nigripes* that were provided abundant prey could overwinter in the Berkeley field cages and in the growth chamber programmed to mimic San Joaquin Valley (KHFS) conditions, establishment of *S. nigripes* in CA ought not to be limited by winter climate. However, this species' sensitivity to the insecticides used in almond orchards and the unreliable availability of adequate and appropriate prey populations seem sufficient to explain why recoveries of *S. nigripes* have never been made beyond a few weeks after release into CA almond orchards. Considerable controversy exists among biological control workers regarding the amount of research necessary prior to and during the introduction of new natural enemies. If establishment and control are achieved, such research obviously is not required ; however, failure to establish new biological control agents leaves many questions. We attempted to answer several questions about *S. nigripes'* biology and ecology so that future speculations on establishment rates might be made on the basis of partial knowledge.

ACKNOWLEDGEMENTS

We thank N. RICHARDSON for collecting *S. nigripes* and F. SKINNER for his careful handling during quarantine. C. SUMMERS and R. COVIELLO provided KHFS weather records ; J. MCMURTRY, K. HAGEN, C. HUFFAKER and D. ROSEN reviewed earlier drafts of the manuscript. This work was supported in part by the Almond Board of California and by Experiment Station Project 3522H.

RÉSUMÉ

Évaluation de *Stethorus nigripes [Col. : Coccinellidae]* comme agent de lutte biologique contre les tétranyques des vergers d'amandiers en Californie

Stethorus nigripes KAPUR (= *S. loxtoni* BRITTON & LEE) a été importé d'Australie en 1978 et lâché en Californie en 1978-1980. Par des essais en cage en laboratoire et dans la nature on a évalué les aspects de la biologie de *S. nigripes* susceptibles d'intervenir dans l'établissement de ce prédateur. Ces études ont montré que la plupart des femelles ne se reproduisent plus en fin d'automne. L'arrêt de reproduction des femelles ne paraît pas être une véritable diapause mais peut être du au froid subi par les nymphes. La survie des 2 sexes pendant l'hiver est faible s'ils n'ont pas à leur disposition d'abondantes proies ; l'eau et le miel seuls ne conviennent pas. Les adultes et les larves de *S. nigripes* n'ont pas pu s'alimenter aux dépens des œufs de *Panonychus ulmi* (KOCH) ou de *P. citri* (MCGREGOR) et ont évité tous les stades de *Bryobia rubrioeulus* (SCHEUTEN) dans les essais en laboratoire ; ce n'est donc pas un prédateur "généraliste" des tétranyques. *S. nigripes* est sensible aux pesticides utilisés pour la lutte contre les principaux ravageurs de l'amandier, y compris au pyréthrinoide, la perméthrine (la concentration léthale 50 est de 0,48 g pour 100 l d'eau).

On a arrêté les lâchers pour l'établissement de ce prédateur après 3 ans, du fait de la sensibilité de *S. nigripes* aux pesticides et de ses exigences en proies pendant l'hiver qui semblent suffisantes pour présumer d'un échec. Même s'il s'installe, ces facteurs empêcheront *S. nigripes* de devenir un prédateur efficace des tétranyques dans les vergers californiens d'amandiers traités par des pesticides.

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