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THE ESTABLISHMENT OF *CHILOCORUS KUWANAE* (COLEOPTERA: COCCINELLIDAE) IN EASTERN UNITED STATES

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Abstract.—The coccinellid *Chilocorus kuwanae* (Silvestri) was introduced from the Republic of Korea into the Washington, D.C. area in 1984 as part of an Agricultural Research Service project for the biological control of diaspine scales. The beetle was released on euonymus trees and shrubs infested with the euonymus scale, *Unaspis euonymi* (Comstock). By the third year after release, the beetle had greatly increased in number and had drastically reduced the population of the scale on the test plants. A brief review of the biology of the beetle is given, and a morphological character is figured to differentiate adults of *C. kuwanae* from the similar native species, *C. stigma* (Say).

Coccinellids are the most important insect predators of diaspine scale insects throughout the world. Species of this family are credited with complete, substantial, or partial control of many species of armored scales (DeBach and Rosen, 1976). Consequently, when the Agricultural Research Service, USDA established a Small Farms Research Project for the control of scale pests, lady beetles were among the prime candidates considered for introduction as part of the biological control effort.

One of the main target insect pests of the project was the euonymus scale, *Unaspis euonymi* (Comstock) (Homoptera: Diaspididae), a very serious pest of many ornamental trees and shrubs throughout much of the temperate region, including the United States (Gill et al., 1982). Because this scale appears to be of Asian origin, the Asian Parasite Laboratory, Seoul, Republic of Korea (ROK), was assigned the task of surveying for, studying, and collecting natural enemies of this scale in Asia.

The coccinellid *Chilocorus kuwanae* (Silvestri) was among the 10 or more species of biotic agents associated with this scale in Korea. Eventually the predator was shipped to the United States and released at various locations in eastern United States. This report documents the establishment of the coccinellid in the eastern states and furnishes biological data relating to the species.

Distinguishing Features

The exotic *Chilocorus kuwanae* (Fig. 1) is very similar in appearance to *C. stigma* (Say), a native species commonly found on other diaspine scales in North America (Gordon, 1985). Both species are black except for the abdomen and the two elytral spots. These spots are reddish and somewhat laterally rectangular in *C. kuwanae* and are more orange-yellow and round in *C. stigma.* However, for the untrained, the living adults are indistinguishable especially if specimens of only one species are on hand.

For recovery and evaluation purposes,

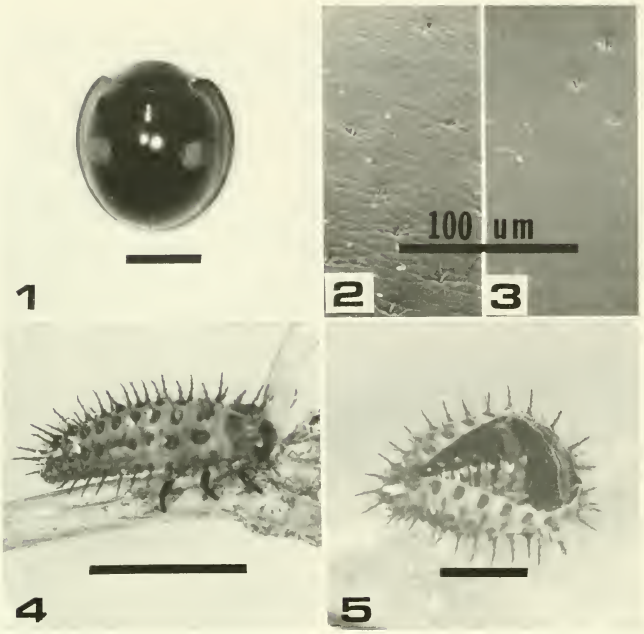

Fig. 1. Adult of *Chilocorus kuwanae*. Fig. 2. Reticulate surface of pronotum of *Chilocorus stigma*. Fig. 3. Smooth surface of pronotum of *Chilocorus kuwanae*. Fig. 4. Third larval instar of *Chilocorus kuwanae*. Fig. 5. Pupa of *Chilocorus kuwanae*. Bars of Figs. 1, 4, 5 represent 2 mm.

there was need for a differentiating character that would require neither dissection nor a direct comparison of specimens of both species. The presence or absence of sculpturing on the pronotum of the adult beetle provided just such a character. Under the high power (100×) of a dissecting microscope the intersetal area of the pronotum of *C. stigma* is distinctly reticulate (Fig. 2), whereas the same area of *C. kuwanae* is smooth and has an oil-like film on living specimens (Fig. 3).

Biology

Several references in the literature describe various aspects of the biology of *C. kuwanae*: Ishii (1937), Nohara (1962), and Xia et al. (1986) give detailed information on the life cycle; Kato (1968) and Xia et al. (1986) report on predation and host range of the species; Tanaka and Kobayashi (1970) review the development and food relationship with the prey; Tanaka and Wada (1973) consider insectary production; and the effectiveness of the species as a natural enemy of scales is given by Zhang (1983). Several species of coccids and aphids are recorded as prey of *C. kuwanae,* but diaspine scales are the most common food of this coccinellid (Kamiya, 1966).

Chilocorus kuwanae is essentially Far Eastern in origin and is widely distributed in China (Xia et al., 1986) and Japan (Kamiya, 1966). According to Clausen (1956) the species was introduced into the United States in Georgia in 1901–1902 under the

name *C. similis,* but the beetle was not recovered after 1905. Smith (1965) reported the same species (i.e. *C. similis*) established in the Santa Barbara area of California from an introduction made in 1923. However, Gordon (1985) considered that the *C. similis* of California is actually *C. kuwanae* and the other records are misidentifications.

As with other species of *Chilocorus* the eggs are deposited singly or in small numbers under empty scale coverings or in cracks and other protected places of the substrate. At room temperature eggs hatch in about 8 days and larvae feed for 2 to 4 weeks, depending upon the availability of food. The larva (Fig. 4) is voracious and will consume several hundred scales during its development (Nohara, 1962).

The pupa (Fig. 5) is formed on the plant where the larva developed. Pupation often occurs in congregations or small groups. This stage lasts for 1–2 weeks, depending on ambient temperatures.

The species overwinters as an adult in protected places on or about the host plant. According to Nohara (1962), activity begins in spring with the onset of warm weather, over 10°C. At our release site, however, beetles were active even on January days if the temperature rose above 10°C. There are three generations per year, but there is an extensive overlapping of all stages during the growing season. Adults are found on plants throughout the year.

Releases and Recoveries

All insects released were from laboratory cultures established from adult beetles collected in Sacheon, Kyeong Sangnam Province, Republic of Korea, on *Euonymus japonica* infested with *U. euonymi.* The shipments from Korea were received through the quarantine facility of the Agricultural Research Service, Beneficial Insects Research Laboratory, Newark, Delaware.

In late September and October, 1984, 171 larvae and 9 adults were released on a euonymus tree, *Euonymus europaeus* L., heavily infested with *U. euonymi* at the United States National Arboretum in Washington, D.C. In October of 1985 an additional 25 adults were released on the same tree. By mid-1986 all stages of the beetle were evident on all the trees of the small grove of euonymus, including *E. hamiltonianus* Wallich var. *nikoensis* (Nakai) Blakelock and *E. kiautschovicus,* about 15 trees on less than 0.5 hectares. From July to October of 1986 more than 400 adults and larvae of *C. kuwanae* were collected from the release site for distribution to other regions in eastern United States, but no apparent reduction of the field population of the coccinellid was observed at the collection site. Therefore, the potential for population growth appears to be great.

Although both adults and larvae were released, the adults tended to disperse and leave the tree. Consequently, the establishment of *C. kuwanae* at the location appears to be the result of the use of larvae for release purposes. Samways (1984), in the use of *Chilocorus nigritus* F. for control of California red scale, *Aonidiella aurantii* Maskell, proposed the release of eggs of the coccinellid to avoid rapid dispersion. Eggs of *C. kuwanae* from laboratory culture were placed on the trees at the Arboretum but no larvae were observed. Failure of this technique is attributed to predation and desiccation.

Very few specimens of the native *C. stigma* were ever recovered from any of the euonymus scale infestations that were studied, although the predator commonly is associated with many other species of diaspine scales in the same general area.

Conclusion

The level of control affected by *C. kuwanae* has not been established, but the visible level of the scale population at the release site is considerably reduced. This

colony of beetles will continue to serve as a source of specimens for redistribution to other areas of the United States.

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