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THE EFFECT OF URBAN AIR POLLUTION ON POPULATIONS OF *EULECANIUM GIG ANTE A* (SHINJI) (COCCIDAE) IN TAIYUAN CITY, CHINA

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ABSTRACT

Great attention has been paid in recent years to biological monitoring of air pollution in the urban environment. This paper presents the results of a study on changes in the population density of *Eulecanium gigantea* (Shinji) (Homoptera: Coccidae) in Taiyuan City, China, where both this soft scale and its host plant, *Sophora japonica,* have been affected by air pollution. The results are as follows: (1) Air pollution in the streets is caused by automobile exhaust gases (such as CO, NO_x, $S0_2$), lead, dust particles and some secondary polluting products (such as photochemical smog and sticky colloidal substances). (2) The scale insect population density (SIP) is positively correlated with the number of cars (Aut. No.) driving in a certain district. The con-elation coefficient is y(SIP) = -15.67 + 0.003695 X(Aut. No.) or *Y* (Aut. No.) = 643.96 + 22.9 X(SIP); the correlation index r = 0.92**. (3) The scale population density varied from 230 per tree at the city center to 10-30 per tree in suburban districts. (4) The highest insect density was recorded in districts with the greatest extent of automotive traffic and the highest dustiness of the air. Medium density was found in residential districts, while the lowest density was in cultural and industrial ones. (5) Insect density was positively correlated with air pollutants, such as total suspended particles, fallout dust, CO, S, NO_x and $S0_2$. It is concluded that the density of the scale insect population can be used for monitoring air pollution in city streets.

KEY WORDS: Coccoidea, Coccidae, scale insects, *Eulecanium gigantea,* urban air pollution, biological monitoring, Taiyuan City, China.

INTRODUCTION

With increased industrialization and urbanization, environmental pollution is becoming a worldwide problem. In recent years scientists have paid great attention to the monitoring of urban air pollution, using plants or animals as indicators. Previous studies [e.g. Edmunds and Allen (1956), Edmunds (1973), Carson and Dewey (1971), Ogiwara (1974), Kawai (1976, 1977), Decourt et al. (1980), Zhou and Chen (1981), Alstad and Edmunds (1982)] have shown that populations of scale insects (Homoptera: Coccoidea) increase when developing in an air-polluted environment. Therefore, we have initiated this study to evaluate the possibility of using the soft scale, *Eulecanium gigantea* (Shinji) (Homoptera: Coccidae), as an indicator for air pollution in the streets of Taiyuan, the capital of Shanxi Province, China.

METHODS

Taiyuan City is a center of energy and heavy industry. Its streets are heavily polluted, mainly by automobiles and other vehicles. The number of vehicles in Taiyuan City increased in 40 years from 75 (1949), 3,463 (1959), 5,260 (1969) and 17,767 (1979) to 77,218 (1989). Exhaust gases contributed CO (100%), SO_2 (100%), Pb (100%) and HC (hydrocarbon) (55%) to the composition of air pollution caused by vehicles. These primary pollutants mix with street dust, forming suspended particles and fallout dust. By a photochemical reaction, secondary pollutants, photochemical smog and sticky colloidal substances are also formed.

We classified Taiyuan streets into four groups (I–IV), according to their width, degree of traffic, number of automobiles and arrangement of the buildings alongside the streets (see Table 1).

The soft scale *Eulecanium gigantea* is widely distributed over northern China (Xie, Xiaoxi, 1985). One of its preferred hosts, *Sophora japonica,* has excellent pollution resistance and is an important ornamental tree there. The soft scale has one generation per year. The adult female has a large hemispherical body. It adheres to twigs and branches, even when dead, and does not drop off for a long time. This provides a simple and convenient method of surveying the scale insect population density (SIP).

After analysis, we selected four pollutant factors: total suspended particles (TSP), fallout dusts (FD), CO and NO_x. Most of the information about pollutant levels was obtained from the Department of Environment (unpublished data). The rest was obtained independently by the authors. Pollutant levels are given in Table 2.

The soft scale population was sampled by counting the adult females in a two-stage sampling technique. First, 10–15 sample trees were selected along certain streets at each investigation site. Then, five sample twigs were taken from each tree and the number of scale insects settled along 60 cm from the tip of the twig was counted.

RESULTS AND ANALYSIS

Correlation between scale density and traffic intensity

The results, listed in Table 1, were as follows: (1) The highest population density of *Eulecanium gigantea* was recorded in the first street group with the maximum automobile number. The density gradually decreased from the first to the fourth street group. (2) At sites such as the Railway Station, the Center Square and Xinjianlukou (a big shopping center with heavy traffic), the SIP was high. (3) A statistical analysis proved that the SIP was positively correlated with the automobile number. The correlation equation was Y(SIP) = –15.67 + 0.003695 X(Aut. No.) or Y(Aut. No.) = 643.96 + 22.9 X(SIP), and the correlation coefficient was $r = 0.92^{**}$.

Interrelation between SIP and the composition of air pollution

The investigation was carried out in four districts of Taiyuan City, and the results, given in Table 2, were as follows: (1) The SIP was positively correlated with high levels of pollutants in the four districts. (2) For each kind of pollutant, the SIP showed a similar trend. Therefore, it may be inferred that each pollutant, or their combination, affected the soft scale populations.

TABLE 1
Interrelation between SIP and number of autocars

Survey site	SG (I–IV)	SIP (No./tree)	Aut. No. (No./h)	Max. Aut. No. (No./h)
Railway Station	I	104.07	3254	4609
City Center Square	I × III	97.00	2361	3561
Youth Road	I × IV	35.08	1543	2222
Dananmen	I × III	50.10	2156	3166
Xinjianlukou	I × III	80.88	2361	3561
Qiaodong	II	38.20	1645	2745
Xinjian Road	III	49.34	1862	2514
Pingyang Road	III	21.87	1457	2263
College Road	IV	1.15	106	208

SG = street group; I × III means the site is at a junction of two streets; SIP = scale insect population density; Aut. No. = number of automobiles; Max. Aut. No. = maximum numbers of automobiles.

TABLE 2
Correlation of SIP with the composition of air pollution

District	SIP (No./tree)	TSP (mg/m^3)	FD (t/km^2)	CO (mg/m^3)	NO_x (mg/m^3)
Traffic	92.7	3.09	197.68	5.4	0.129
Traffic-residential	17.9	1.98	127.12	4.0	0.096
Industrial	13.1	0.82	50.72	2.3	0.045
Cultural	1.3	1.03	53.86	2.5	0.058

DISCUSSION AND CONCLUSION

What are the reasons for the increase in the population of *E. gigantea*? According to the results of our study, it is suggested that air pollution reduced the controlling power of the natural enemies of the scale insect; this was probably the main reason. In Taiyuan City some important natural enemies of the scale are found, for example, the lady beetles, *Coccinella septempunctata* L. and *Chilocorus kuwanae* Silvestri, the parasitoid, *Blastothrix sericae* (Dalman) and a moth, *Beijing utila* Yang. Generally, the two lady beetles have a higher density in suburbs and on farms and keep the scale under control, while in the city their density is lower. Although the parasitic wasp and the larvae of the moth play an important role, their density in the city is lower than in suburban districts.

The second reason is related to the biology of the soft scale. The soft scale secretes a waxy substance over its body surface. After air pollutants and dust fall on the scale, the waxy cover turns thick. This may protect the scale insect against extreme climatic conditions and natural enemies.

In the city, environmental pollution is a complex process, in which the scale insect, its hosts and natural enemies are affected or injured, but the scale insect is more resistant than the other two; therefore, its population may increase continuously.

As shown above, the populations of *E. gigantea* are greatly affected by urban air pollution. The correlation between these two parameters was so highly significant that using the soft scale as a biological indicator may be considered a convenient method for monitoring urban air pollution. Today our environment monitoring procedures still rely mostly on physical and chemical instruments. But air samples fed to instruments are collected only at certain places and times. Collection is often affected by wind, rain and other meteorological factors. Therefore, the results obtained from the instruments reflect a discontinuous and incomplete information, whereas the scale insect and its host trees live continuously in the polluted environment. Therefore, by combining biological and instrumental monitoring methods, we believe that the results will provide much more accurate information for organisms and humans living in the environment.

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