Bull. Inst. Zool., Academia Sinica **17**(1): 69-76 (1977)

POPULATION FLUCTUATIONS OF SOYBEAN MINER, *OPHIOMYIA PHASEOLI* (TRYON)[1,2]

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ABSTRACT

Fei-Jann Lin, Tsing-Cheng Wang and Chao-Yen Hsieh (1977). *Population fluctuations of soybean miner* Ophiomyia phaseoli *(Tryon).* Bull. Inst. Zool., Academia Sinica, **17**(1): 69-76. The population density of *Ophiomyia phaseoli* in 6 successive crop seasons during a period of two years' survey was observed with two peaks for each crop season: one at germination and the other at flowering stage. The factors influencing population density of *O. phaseoli* so far detected are soil moisture, soil pH value, solar intensity and relative humidity. Other abiotic factors are found no correlation with the fly density at Shan-Hua area, southern Taiwan.

Chen, Lee, Chang and Lee, and Wang[15~20] reported that the damages of soybean crops by agromyzid miners in Taiwan are almost over two-third of the planted crops. The above estimation is far below the result of our preliminary surveys on the population fluctuation of soybean miners made three years ago when 99% of bean crops were infested (also personal communication with Ross and Lin, Asian Vege table Development and Research Center). Meanwhile we found young crops were destroyed by the miners during the plant germination. In a survey on March 19, 1975 an average of 470 young soybeans planted in each quadrat with surface area of 5 m^2 were observed, but later on April 10, 1975 only average of 110 young plants were remained alive in the same field. In other words, the rate of damages by the soybean miner during the young stage of the crop is about 75%.

Although insecticides, such as Furadan, Parathion, Malathion, Azodrin, Vydate, Hostathion, have been heavily applied on the bean crops to control the pest, but no effective results were achieved[15~21]. It was shown that the use of insecticides to control agromyzid miners is very limited and still left the severe damage of the bean crop by the miners.

The main purpose of this study is focused on the population fluctuation of the pest in relation to their abiotic factors in order to search the main key factor or factors which interact with the pest population density.

1. Paper No. 180 of the Journal series of the Institute of Zoology, Academia Sinica.
2. Grants were supported by JCRR Contact Nos. 75-A11-A-2485(C) and 76-A12-A-2546(A) to FJL.

TABLE 1

Date, abiotic factors and density of *Ophiomyia phaseoli* recorded for a bean field at Shan-Hua, Taiwan. Fly density is represented as the numbers per 50 m^2 (10 quadrats)

Date of sampling	Planting season	Fly density	Soil moisture (%)	Soil pH	Soil temp. 10 cm deep (°C)	Solar intensity (Cal/cm²)	Relative humidity (%)	Wind velosity (km/hr)	Preci-pitation (mm)	Air temp. (°C)	Evapo-ration (mm)
1975											
March 19	1	5	16.51	7.76	22.8	296.0	77.5	163	2.30	23.4	3.80
April 10	1	4	14.28	6.81	26.9	575.2	79.0	66	0	25.8	6.30
April 21	1	39	3.53	6.63	29.3	582.0	73.0	93	0	28.1	8.50
April 30	1	43	20.26	6.99	28.5	564.4	81.0	81	0	27.1	6.20
May 2	1	38	4.43	6.05	29.7	378.0	83.0	82	0	27.3	5.60
May 23	1	114	19.07	6.50	28.5	247.2	83.0	55	4.57	26.0	2.47
June 4	1	64	6.98	6.94	30.7	356.0	81.0	121	7.11	28.1	3.81
June 18	1 and 2	6	18.87	7.10	30.9	606.0	83.5	99	0	28.7	7.40
July 15	2	14	17.47	6.92	30.8	356.0	86.5	99	24.89	28.0	4.29
July 25	2	13	12.13	6.46	31.5	498.0	82.0	90	0	28.3	6.20
Aug. 5	2	20	18.97	6.31	30.1	440.0	82.0	43	0	28.6	3.50
Aug. 16	2	—	—	—	30.0	48.0	100.0	277	341.12	25.0	—
Sept. 2	2	126	7.10	6.77	32.0	560.0	76.5	—	17.78	29.5	8.88
Sept. 20	2	72	14.40	7.02	31.3	460.0	82.0	76	0	28.4	4.90
Oct. 6	2 and 3	68	16.57	6.74	28.5	352.0	80.5	69	0	27.8	5.20
Oct. 21	2 and 3	134	7.97	6.46	28.5	276.0	82.5	61	1.27	25.6	3.17
Oct. 30	2 and 3	74	5.73	6.45	28.0	312.0	80.5	200	0	23.5	6.10
Nov. 14	3	130	1.87	5.73	26.2	260.0	80.0	87	0	24.3	3.10
Dec. 3	3	93	8.73	6.64	—	—	—	—	—	—	—
Dec. 23	3	14	12.07	6.84	—	—	—	—	—	—	—
1976											
Jan. 9	3 and 4	9	8.67	6.47	17.4	344.0	76.0	150	0	15.7	3.10
Jan. 23	4	6	4.67	6.12	18.7	284.0	83.0	151	3.20	14.1	0
Feb. 9	4	31	4.60	6.24	19.3	416.0	73.5	109	0	17.4	4.60

Feb. 28	4	38	7.87	6.20	22.6	412.0	74.0	148	6.35	24.9	8.85
March 16	4	34	2.70	6.28	25.7	440.0	76.5	97	0	24.7	6.80
March 28	4	56	3.77	7.41	24.0	484.0	81.0	105	0	24.3	5.60
April 13	4	143	3.53	7.18	24.3	244.0	78.5	56	14.73	23.3	4.73
April 24	4	89	1.90	6.71	26.2	540.0	76.0	62	0	22.1	6.20
May 8	4	28	18.07	7.94	26.4	372.0	75.0	32	0	25.6	5.00
May 23	4 and 5	14	6.93	6.86	30.0	540.0	81.0	131	1.27	28.4	7.77
June 9	4 and 5	43	8.07	7.27	29.0	592.0	78.0	115	0	27.7	7.70
June 26	5	75	12.20	6.84	31.0	360.0	85.0	51	22.10	28.0	5.30
July 10	5	4	12.42	6.88	29.6	608.0	84.0	71	0	27.6	6.80
July 29	5	31	3.40	6.29	30.7	564.0	83.0	67	7.11	27.6	7.81
Aug. 16	5	27	16.57	6.56	30.6	532.0	85.0	52	0	28.2	6.10
Aug. 29	5 and 6	40	15.24	6.66	30.3	532.0	82.0	—	0	28.0	5.80
Sept. 10	5 and 6	114	3.24	6.05	30.7	536.0	76.0	82	0	26.2	7.10
Sept. 25	5 and 6	124	14.25	5.76	29.9	188.0	87.0	83	19.56	26.5	3.96
Oct. 12	6	300	2.13	6.31	28.6	452.0	76.0	63	0	25.5	5.70
Oct. 27	6	112	4.82	6.37	28.2	400.0	73.0	70	0	25.8	4.50
Nov. 12	6	178	3.49	6.01	25.5	332.0	73.0	93	0	22.0	4.30
Nov. 27	6	176	12.08	6.67	21.7	300.0	70.0	197	0	16.6	5.20

Typhoons have attacked this area on August 5, 1975; August 15, 1975; September 22–23, 1975 and August 9, 1976. Heavy raining came on June 5 to 15, 1975; June 25 to 28, 1975; August 17 to 20, 1975; September 11, 1975; October 5 to 7, 1975; May 27 to 31, 1976; July 2 to 6, 1976; August 2 to 5, 1976; and September 25 to 26, 1976 in this area.

TABLE 2

Significant probabilities for the correlation coefficient (r) between population density of *Ophiomyia phaseoli* with its abiotic environmental factors

Correlation coefficient (r)	Soil moisture	Soil pH	Soil temperature	Solar intensity	Relative humidity	Wind velosity	Precipitation	Air temperature	Evaporation
Population density	0.3653***	0.3066***	0.0410	0.3398***	0.3218***	0.0843	0.0918	0.0757	0.1106

*** indicates significant level at 0.001

MATERIALS AND METHODS

Temporary aggregated dispersion pattern was observed during their matings of the miner in the early morning between 8:33 a. m. to 9:30 a. m. Therefore, our measurement of population density of the adult flies was conducted between 10:00 a. m. to 10:30 a. m. on each sampling day at Shan-Hua, southern Taiwan. The numbers of flies dispersed in a quadrat size of 5 square meters were measured, then the fly density was represented by the fly number occurring in an area of 50 m^2 (or 10 quadrats) as shown in Table 1. Because of the fly moves very quick our measure of the fly numbers was carefully counted as soon as possible (about one to two minutes) to eliminate the sampling bias to prevent the fly comes in and out of the sampling area. Sometimes the fly stays under leaves and in shadows so careful attention on each cases should be paid during the measurement. Ten different locations of soil sample taken from 10 cm. deep were stored in a sealed plastic bag to avoid the evaporation of the soil water. The soil samples were brought back to the laboratory for the analyses of pH values and water contents. The insecticides and herbicides, or their residues on the soil were not taken into account. The data of air temperature, relative humidity, precipitation, soil temperature of 10 cm. deep, solar intensity, wind velosity and evaporation of soil water were provided by Asian Vegetable Development and Research Center. The above records together with soil pH value and soil moisture were shown in Table 1 also. Special attention was paid during the field observation the double checks with all resources we obtained were done. Data were analysed for the interactions of the population density of the fly to the environmental factors. Correlation coefficient and probabilities of significance were calculated and the results are shown in Table 2. Parasites and predators of the bean fly were also recorded but no intention here to mention them in this report.

RESULTS AND DISCUSSION

Taxonomic status of *Ophiomyia phaseoli*:

The species was first described by Tryon in 1895 from Australia and named *Oscinis phaseoli*. Same fly was determined by Coquillett in 1899 with the name of *Agromyza phaseoli* from New South Wales, Australia. *Agromyza fabris* by Jack in 1913 from Rhodesia and *Agromyza destructor* by Malloch in 1914 from Formosa (Taiwan) and Philippines were found to be synonym of Tryon's specimen[12]. Spencer[13] has revised the family Agromyzidae of the Pacific area and shifted this species to genus *Melanagromyza*. With the careful study of the male genitalia to compare with other related species in the family, Spencer[14] concludes that the species is belonging to genus *Ophiomyia*, thus the correct name of the fly should be *Ophiomyia phaseoli* (Tryon).

***Ophiomyia phaseoli* and its related species and their host plants and parasites:**

The related species with *O. phaseoli* which depend on bean crops are *Japanagromyza tristella* (Thomson) (synonym as *Agromyza varrihalterata* Malloch), *Melanagromyza alternata* Spencer, *M. dolichostigma* de Meijere (synonym as *M. decor* de Meijere), *M. obtusa* (Malloch) (synonym as *M. weberi* de Meiejre), *M. producta* (Malloch), *M. sojae* (Zehntner) (synonym as *Agromyza prolifica* Malloch) and *Tropicomyia atomella* (Malloch) have been reported from Taiwan[7,13]. Host plants of these agromyzid pests almost include whole family of Leguminosae. Such plants are *Cajanus indicus* Spreng. (樹豆), *Calopogonium mucunoides* Desv., *Canavalia ensiformis* DC. (刀豆), *Centrosema pubescens* Benth., *Crotalaris juncea* Linn. (貍豆), *C. mucronata* Desv. (大葉野百合), *Dolichos sesquepedalis* Linn. (長豇豆、扁豆、天竺豆、菜豆), *Flemingia* spp., *Glycine max* Merrill (黃大豆、黃豆、毛豆), *G. sojae* Sieb. et Zucc. (蔓豆、虠豆), *Indigofera suffruticosa* Mill. (木藍、胡豆), *I. sumatrana* Gaertn. (南洋木藍), *Lablab niger* Linn. (黑豆), *Medicago sativa* Linn.

(紫苜蓿), *Melilotus* sp., *Phaseolus atropurpureus* DC., *P. calcaratus* Roxb., *P. lunatus* Linn. (皇帝豆), *P. mungo* Linn. (綠豆), *P. radiatus* Linn. (八重生、文豆), *P. panburatus* Mart. (蔓小豆、蟹眼豆), *P. vulgaris* Linn. (四季豆、敏豆), *Pisum sativum* Linn. (豌豆、荷蘭豆), *Pueraria javanica* Benth. (爪哇葛藤), *P. thunbergiana* Benth. (臺灣葛藤), *Swainsonia galegifolia* (And.), *Vigna catjang* Walp. (短莢豇 豆), and *V. unguiculata* (Linn.)[4,8]. The most favorable Leguminosae plants for *Ophiomyia phaseoli* are *Cajanus indicus*, *Canavalia ensiformis*, *Crotalaria juncea*, *C. mucronata*, *Dolichos sesquepedalis*, *Glycine max*, *G. sojae*, *Lablab niger*, *Phaseolus atropurpureus*, *P. calcaratus*, *P. lunatus*, *P. mungo*, *P. panduratus*, *P. radiatus*, *P. vulgaris*, *Vigna catjang* and *V. unguiculata* (=*V. sinensis*). Although *O. phaseoli* attacks most species of *Phaseolus* aud many genera of Leguminosae, but its range is limited[14]. According to van der Goot[4] genera *Cassia*, *Centrosema*, *Desmodium*, *Flemingia*, *Indigofera*, *Lupinus*, and *Pisum* of the family Leguminosae and *Phaseolus sublobatus* are immune to be attacked by *O. phaseoli*.

Psrasitic hymenopterans on *O. phaseoli* have been reported from Hawaii, Java[11], India[1,2], Philippines[3], Mauritus[10], Rhodesia[14], East Africa[5], Australia[8], Iraq, Israel[5] and Egypt[6]. Those hymenopterans include Baraconidae: *Opius oleracei* Fischer, *O. phaseoli* Fischer, *O. liogaster* Szep., *O. malanagromyzae* Fischer and *O.* sp. from East Africa; Chalcididae: *Merismorella shakespearei* Girault; Cynipidae: *Cynipid* sp. from Java; Eulophidae: *Achrysocharis donglassi* Girault, *Hemiptarsenus semialbiclavus* Girault, *H.* sp. from Australia, *Neodimmockia agromyzae* Dodd; Eupelmidae: *Eupelmus gravi brevicinctus* Girault; Eurytomidae: *Eurytoma paloni* Girault, *E. larvicola* Girault, *E.* sp. from Java, *E.* sp. from Australia; Pteromalidae: *Eurydinotellus viridicoxa* Girault, *Polycystomyia benefica* Dodd, *Pterosema subaenea* Dodd and *Trigonogaster agromyzae* Dodd. The most destructive parasites to *O. phaseoli* are *Opius phaseoli*, *O. melanagromyzae*, *Trigonogaster agromyzae* and *Eurytoma lavicola* have been reported[14].

Mining courses of *Ophiomyia phaseoli* on bean crops and its life cycle:

The eggs of the miner lay on either surfaces near the base of young leaves and flower buds and occassionally on the short leaf steam throughout the year. A single female may oviposit between 100 to 300 eggs over a two week period of its adulthood[11], The eggs will hatch within 2 to 4 days depend on the seasonal temperature changes. The larva forms a short leaf-mining then enters the nearest vein which is followed into the petiole and down into the pith of the stem.

The larva will feed down into the upper part of the root through the pith inside the stem. In most cases, the larva will be grown up to pupa only fed one section between two foliage stems. If the plants are just germinated and at the newly forming stage, the plants will be largely destroyed (75% destroyed) and can only survive if the adventitious root develop fast enough to their total collapse. The larva will feed in the pith of the stem for 9 to 12 days accordingly and always pupates at the bottom of its mining path. One can easily inspect whichever part of the plant attacked by the miner from checking a small hole under the foliage branches. Sometimes as many as 8 holes on the stem of a plant were observed. Pupa will stay in the pith for about 9 to 10 days depend on the abundance of food and favorable air temperature. The longevity of adult flies were observed ranging from 5 day to 2 weeks. The flies can be mated 24 hours after their imergence. *O. phaseoli* completes its life cycle in 25 to 28 days.

Population fluctuation of *Ophiomyia phaseoli:*

Population fluctuation of *Ophiomyia phaseoli* are shown in Table 1 and Fig. 1 in comparison with environmental factors. As shown in the Figure, the fly density appeared to have two peaks, one at germinating period and one at flowering stage of the plant during each crop season. The calculation of population density versus its environmental factors: soil temperature, soil pH value, soil moisture, solar in-

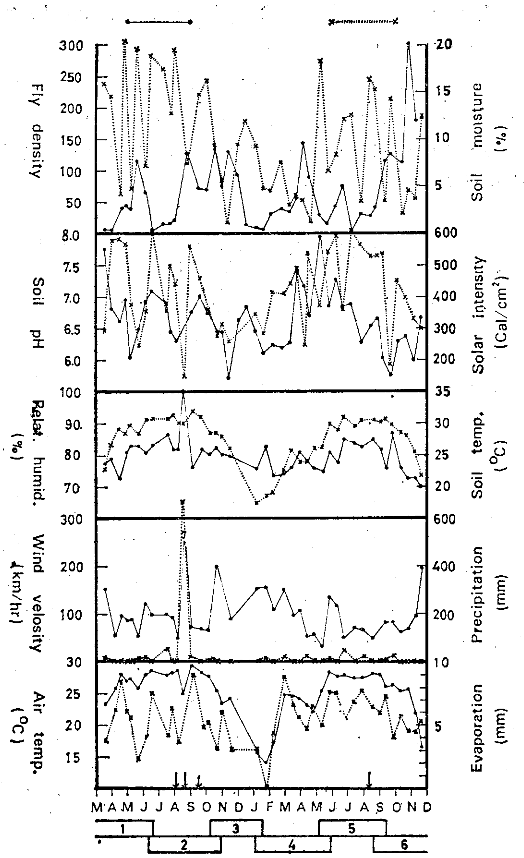

Fig. 1. The fluctuations of the density of *Ophiomyia phaseoli*, soil moisture, soil pH value, solar intensity, relative humidity, soil temperature, wind velosity, precipitation, air temperature and evaporation. Typhoon indicated by arrows. Successive soybean plantings shown by numbered horizontal bars.

tensity, relative humidity, wind velosity, precipitation, air temperature and evaporation of soil water, correlated coefficients are shown in Table 2 and Fig. 1. The significant probabilities for the correlation coefficient (r) between density of *O. phaseoli* and the environmental factors (Table 2) such as soil moisture (0.3653), soil pH value (0.3066), solar intensity (0.3398), and relative humidity (0.3218) showing high significance at the level of 0.001 respectively. There is no correlation with soil temperature (0.0410), wind velosity (0.0843), precipitation (0.0918), air temperature (.0757), or evaporation (0.1106). From the field observation throughout two years period, precipitation was found to kill some flies but the result showed no correlation with the downfall of fly density. Air temperature in this area is high throughout the year resulting a more stable fly density. The more suitable temperature for *O. phaseoli* calculated is 27.1°C and the average in this area is recorded as 25.4°C. From January to March the temperature ranged from 17.4°C to 22.8°C which is far below calculated optimal temperature for the fly, actually the fly number is greatly reduced. The heavy rains came on June and July, the fly density goes down and keeps relatively small numbers. Typhoon also kills some flies when blows in this area but the population number seems to recover very fast. At the interval of two week-period of samplings no effect of the population density versus rain fall was detected.

The fly favors dry season when soil moisture is low and the fly number increases as shown in Table 1 and Fig. 1. If soil moisture keeps under 10% of water content, the fly seems to be more abundant. During the raining season between June and July, soil water conients are high, consequently the fly density declines althought the temperature during the period is optimal for the fly. The irrigation of water in the bean crop field may be a good factor to reduce the fly density, the more water content in the soil the less fly number will be.

The bean crops are usually planted on the soil with a pH of 6.8 as suggested by plant breeders. Because of the good association with bean crops, the fly is predicated to favor relatively acidic environment. From the results obtained the optimal pH value for the fly is 6.67. Bean breeders used to apply calcium carbonate on the soil before planting which sounds a good factor to reduce the survival rate of the miner. Irrigation after the germination of bean crops could change the soil acidic phase to more neutral or alkaline form, consequently this could reduce the fly density. In one case, the fly was counted only 5 in the area of 10 quadrats at the soil pH value of 7.76. In such situation we could not have any effort to change the soil pH to alkaline form which will not suit for the bean crops. The coevolution between bean crops and bean fly is a very interesting theme. Fig. 1 shows that the fluctuations of soil pH with seasons suggested that pH value below 6.00 or above 7.50 are harmful to the fly, and this will reduce the fly density. The behavior of the fly is phototrophic so the higher solar intensity will favor for the survival of the fly. Fig. 1 also shows that higher solar intensity in this area presents seasonal changes. The higher temperature in the late spring, summer and autumn is associated with the solar intensity. Interestinly the fly population density is correlated with solar intensity owing to the phototrophic behavior of the fly.

We have already discussed earlier the fly would prefer a relatively dry environment, higher humidity, of course, will not be a suitable factor for the fly. The result (Table 2) shows that the fly density goes down when the humidity is high ($r=0.3218$, $p<0.001$). Same pattern was also observed for the relation between fly density and soil water contents (soil moisture) ($r=0.3656$, $p<0.001$). The correlation of the fly density with the rest of environmental factors are not significant at all (soil temperature: $r=0.0401$, $p>0.1$; wind velosity: $r=0.0843$, $p>0.1$; precipitation: $r=0.0918$, $p>0.1$; air temperature: $r=0.0757$, $p>0.1$ and evaporation: $r=0.1106$, $p>0.1$).

The population density of adult *Ophiomyia phaseoli* counted from the 10 quadrats sampling field ranged between 4 and 300 flies during the two years period. Presumely each bean crop is infested by one fly then there will be 110 flies in each quadrat of 5 square meters. The total flies attacked bean crops in the 10 quadrats will be 1100 flies. The counted 300 flies were far below the maximum population density (1100 flies) of the miner. We may conclude that the effects on the reduction of the total fly numbers in the bean field we employed are insecticide application, colder weather, irrigation, parasitism of hymenopterans and insectivores (birds, spiders and other insects). The effect of other controlling measures on bean fly population density remains to be done.

CONCLUSION

(1) The population density of *Ophiomyia phaseoli* in 6 successive crop seasons during a period of two years survey was observed. There are two peaks for each crop season: one at germination and the other at flowering stage.

(2) The factors influencing population density of *O. phaseoli* so far detected are soil moisture, soil pH value, solar intensity and relative humidity. Other abiotic factors, such as soil temperature, wind velosity, precipitation, air temperature and evaporation of soil water are found no correlation with the fly density.

(3) The largest density counted on a sampling day was 300 flies per 50 m^2 (10 quadrats), that is far less than the estimated hypothetical maximal density of 1100 flies. The factors causing the reduction of population density are not only by what we have analysed but also by other components, such as insecticide application, other unpredictable weather conditions, predations and parasitisms which we did not demonstrated.

(4) The fluctuation of fly density is associated with bean crop's growing phases, since this fly is specific to bean crop so the companion croppings may reduce the fly density.

Acknowledgements: The authors wish to express their thanks to Misses Fang-Jong Hsu and Hwei-Yu Chang for technical assistance. Mr. Chi-Yong Su, AVDRC, providing us the weather records of Shan-Hua area is most grateful. Thanks also to JCRR for the financial support during the two years investigation.

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大豆莖潛蠅 (*Ophiomyia phaseoli*) 族羣變動之研究

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本文介紹在兩年期間裡於臺南縣善化調查了六季大豆生長期之大豆莖潛蠅之族羣變動狀況，發現該蠅之族羣數目在大豆發芽時期和開花時期爲最高。同時討論了大豆莖潛蠅與非生物環境之相關關係，發現在該地區能够影響蟲數之非生物因子爲土壤濕度、土壤酸鹼度、陽光强度和相對濕度。文中亦介紹了該蠅之分類地位、生活史、寄生植物和寄生於該蠅之寄生蜂。