

Studies on Relative Densities of Cockroach Populations in 7 Different Habitats by Using Sticky-Traps in Suwon

끈끈이 트랩(Trap)을 이용한 수원시내 바퀴 개체군의
서식처별 상대밀도 조사

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ABSTRACT Cockroach survey on the relative density from 7 different habitats including hotel-inns, tea-rooms, restaurants, hospitals, apartments, and resident houses were conducted in 3 District(Ku) areas in Suwon city during the period of February through October, 1994. Of a total of 3,039 trap sets, Cockroaches were collected from 1,435 traps, comprised of 47.22% positive trap-rate. Chinese restaurants were shown to be the highest positive trap-rate of 72.67% of the total while the other habitats such as Korean restaurants, apartments, resident houses, tea-rooms, hotel-inns, and hospitals were 60.67%, 58.61%, 52.22%, 38.67%, 24.88%, and 17.54%, respectively. *Blattella germanica* was shown to be the highest population density of 55.01 individuals/trap/week comprised of 97.36% of the total during survey period whereas the other 3 species, *Periplaneta japonica*, *P. americana*, and *P. fuliginosa* constituted in lesser extent of 2.35%, 0.14%, and 0.14%, respectively. Of a total of 7 different cockroach breeding habitats, higher population density per trap/week was from restaurants with averages of 20.56 and 8.31 cockroaches from Chinese and Korean restaurants, respectively. An intermediate extent of density was observed from apartments, tea rooms and resident houses with 5.33, 3.79 and 3.53 individuals, respectively. Lower relative densities of cockroaches were observed from hospitals and hotel-inns with averages of 0.18 and 1.00 individuals per trap/week, respectively.

KEY WORDS Cockroaches, sticky-traps, different habitats, positive trap rate, relative density, species composition.

초 **록** 수원 지방에서 서식하는 바퀴의 종류와 상대밀도를 조사하기 위하여 수원 시내 7개 다른 서식처, 여관, 다방, 중식 음식점, 한식 음식점, 개인 병원, 아파트, 그리고 단독주택을 선정하여 끈끈이 트랩에 의한 바퀴의 채집과 서식처별 상대밀도조사를 1994년 2월부터 11월까지 실시하였다. 설치된 3,039 개의 트랩 중 1,435개의 트랩에서 한마리 이상의 바퀴가 채집된 Positive Trap Rate(양성 트랩율)은 47.22%였다. 중식 음식점에서의 양성트랩율은 72.67%이었고, 채집된 바퀴의 수가 전 채집개체의 48.84%로 바퀴오염이 가장 심한 빈도를 나타내었다. 그에 비하여 한식 음식점, 아파트, 단독주택, 다방, 여관, 그리고 병원에서는 보다 조금 낮거나 매우 낮은 60.67%, 58.61%, 52.22%, 38.67%, 24.88% 그리고 17.54%로 각각 나타났다. *B. germanica*는 전 채집개체 수의 97.36%로 가장 높은 밀도를 나타내었으며, 55.01 개체/트랩/주의 평균 밀도를 보였다. 반면, 다른 종인 *P. japonica*, *P. americana*와 *P. fuliginosa*는 이보다 훨씬 낮은 2.35%, 0.14%, 0.14%를 보였다. 7개의 서로 다른 서식처에서 개체군 밀도를 조사해 본 결과 중식 음식점과 한식 음식점에서 20.56과 8.31개체/트랩/주라는 보다 높은 개체군 밀도가 관찰되었다. 그에 비해 아파트, 다방과 단독주택에서는 5.33, 3.79와 3.53 개체/트랩/주의 중간범위의 밀도가 조사되었고, 비교적 낮은 밀도가 병원(0.18 개체/트랩/주)과 여관(1.00 개체/트랩/주)으로 부터 관찰되었다.

검색어 바퀴, 끈끈이 트랩, 7 다른 서식처, 양성 트랩율, 상대밀도, 종구성.

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Cockroaches are one of the insects of medical importance that have well adapted to a variety of circumstances. It was reported that approximately 4,000 cockroach species were reported throughout the world (Lane and Crosskey, 1993).

Rehn (1945) pointed out that the majority of cockroach species are not domiciliary pests, and the important pest species constitute considerably less than one per cent of the total cockroach species reported (Harwood and James, 1979; Ree, 1993). The remainder of the species are found largely in the tropics and subtropics in a variety of situation where they live among or under decaying leaves or other plant debris, under rubbish or stones, on flowers, leaves, trees, in caves or burrows, in the nests of birds, etc. (Cornwell, 1968). Many species were reported to be diurnal in contrast to the nocturnal habits of most common domiciliary pests of medically important, and certain of the tropical forms fly quite well

Cockroaches have been known to be the most obnoxious insects to man. The presence of roach was used to be considered a potential public health hazard because of their capability to transmit disease organisms mechanically to various food sources of man and livestock (Alcama and Frishman, 1980). While, the presence of cockroach is aesthetically unacceptable to man. Cockroaches were usually regarded as loathsome pest because of their appearance and distasteful odour.

German cockroaches, *Blattella germanica* (L.), have been considered to be the important household insect pest in Korea (Shin *et al.*, 1973; Ree, 1993). Recent study on population dynamics of cockroach in Pusan by Chon and Kwon (1991) indicated that mean densities per trap per week ranged 0.7-41.9 individuals

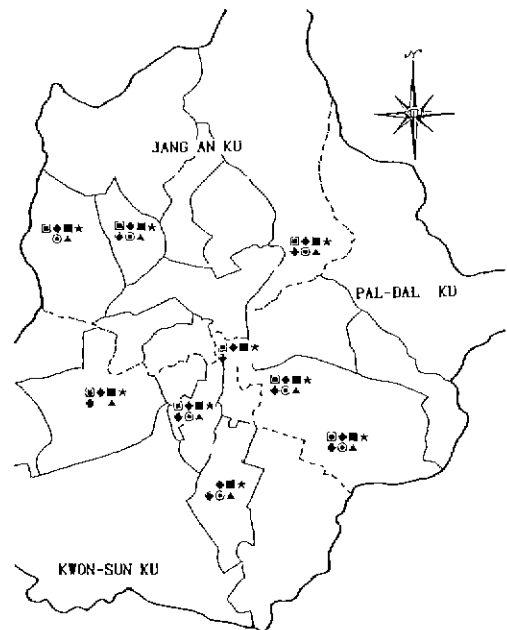
It has been reported that there were many factors contributing to the problems of cockroach infestation which included the lack of cleanliness of housekeeping (Chon and Kwon, 1987) and the emergence of insecticide resistance of cockroaches to a few commonly available insecticides. Therefore, it was suggested that the importance of ecological investigation on cockroach population and their influencing factors were gradually emphasized, particularly for the

application to the integrated suppression of the main pest species of cockroaches (Schal and Hamilton, 1990).

This report discusses species composition and relative density of cockroaches collected from 7 different breeding habitats such as hotel-inns, tea-rooms, restaurants, hospitals, apartments and resident houses in Suwon city by using sticky-traps. It was needed to determine, (1) the predominant species in Suwon city, and (2) the relative density of each species by 7 different habitats and by month

MATERIALS AND METHODS

Sticky-traps (18×9.5×15 cm) commercially available were used to determine relative densities and the species composition of cockroach population from 7 different habitats in Suwon city from Feb-



Figs. 1. The map showing trap sites distributed in 9 Dongs of 3 Districts(Ku) to determine relative densities, and species composition of cockroaches collected by using sticky-trap from 7 different habitats in Suwon, Korea, February through October, 1994.

■ Hotel-inn, ◆ Tea-room, ■ Chinese restaurant, ★ Korean restaurant, ◇ Hospital, ● Apartment, ▲ Resident house.

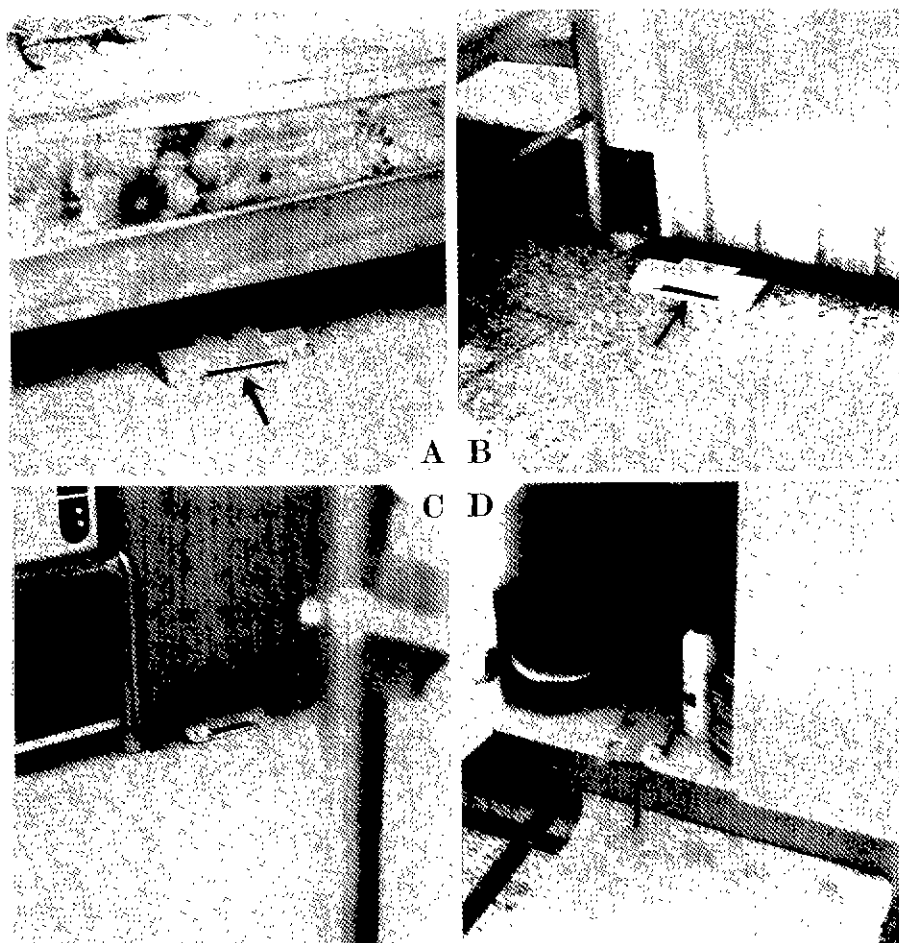


Fig. 2. Loci of sticky-traps where cockroaches were collected in different breeding sites: A, underneath of bed of the hotel-inn; B, underneath of counter of the restaurant; C, underneath of private cabinet of the hospital; D, under the sink of the house kitchen.

ruary through October, 1994. Three traps were set in one of the habitats randomly chosen and they were exposed to last for 7 days twice a month.

To determine relative densities and the species composition of cockroach population, 7 different habitats were selected at random at each of the 9 Dong of 3 District areas in Suwon City (Fig. 1). The habitats of cockroaches collected were hotel-inns, tea-rooms, restaurants(Korean and Chinese), hospitals, apartments and resident houses. A total of 60 trap sites representing 7 different habitats were selected for trap-setting (Fig. 2).

In setting sticky-traps, restaurants and tea-rooms were separately set in the kitchen, bedroom and

hall, while in hotel-inns and hospitals the traps were set under bed and cabinet, and in apartments and resident houses the traps were separately set in the kitchen, bedroom and dining room

Observations were carried out twice a month and traps were exchanged biweekly. The cockroaches collected were brought back to the laboratory and identified (Cornwell, 1968; Ree, 1993) and counted for each of the growth stage (Tanaka and Hasegawa, 1979)

In measuring the number of cockroaches collected, the 1st nymphal stage was excluded because of certain difficulties in determining during the laps of time after the collection and being hatched in

the laboratory. Number of egg cases were counted and tabulated for an average per trap per week.

RESULTS

Positive Trap Rates

In this study period, a total of 3,039 sticky-traps was set in 7 different habitats, and the number of positive traps where cockroach collected were 1,435 which comprised of 47.22% (Table 1) The results of positive trap rate among 7 different habitats showed the highest was observed from Chinese restaurants constituting 72.67% of the total, while the lowest observed was hospitals of 17.54% (Table 1). Relatively higher rates were observed from Korean restaurants, apartments and resident houses constituted 60.67, 58.61 and 52.22%, respectively. Tea-rooms and hotel-inns were observed comparatively lower positive rates of 38.67% and 24.88%, respectively.

Species Composition and Relative Density of Cockroaches by Month

During the survey period, species of cockroaches collected by sticky-trap were a total of 4 species, *Blattella germanica*, *Periplaneta japonica*, *Periplaneta americana* and *Periplaneta fuliginosa* (Table 2). German cockroaches (*Blattella germanica*) were shown the highest population density with constituting 97.36% of the total, and this species was the most and problematic species, while the other 3 species (*P. japonica*, *P. americana* and *P. fuliginosa*) were only 2.35%, 0.14% and 0.14%, respectively (Table 2).

B. germanica was shown to have higher population density in February with an average 4.68 individuals/trap/week, and gradually increased in Spring and peaked in July as 6.66 individuals/trap/week, which thereafter, slightly decreased but the high population was also shown in October with an average number of 12.91 individuals/trap/week (Table 2).

P. japonica was shown to have the higher population density constituting 2.35% of the total with an average number of 1.31 individuals/trap/week, and also showed an average of 0.26 in May, which thereafter, slightly decreased and peaked again in

October with an average number of 0.32 individuals/trap/week (Table 2 and Fig. 3).

P. americana was shown to have relatively low population density and emerged in April with an average number of 0.01 individuals/trap/week, and similarly maintained until September with an average number of 0.01 individuals/trap/week (Table 2).

Species Composition and Relative Density by 7 Different Habitats

Of a total of 7 different cockroach breeding habitats, the higher population density per trap/week was from restaurants, resulted in with averages of 20.56 and 8.31 individuals from Chinese and Korean restaurants, respectively (Table 3 and Table 4).

As shown in Table 3 and 4, a total of 4 species of cockroaches, *Blattella germanica*, *Periplaneta japonica*, *P. americana* and *P. fuliginosa* were collected from Chinese restaurants of which *B. germanica*, the German cockroach being comprised of 97.33% of the total roaches collected from the habitats; while from Korean restaurant, 3 species not inclusive of *P. americana* were collected with German cockroach being 96.51% of the total as was evidenced from Chinese restaurant.

Cockroach population density appearing an intermediate extent ranging 3.5-5.5 individuals per trap

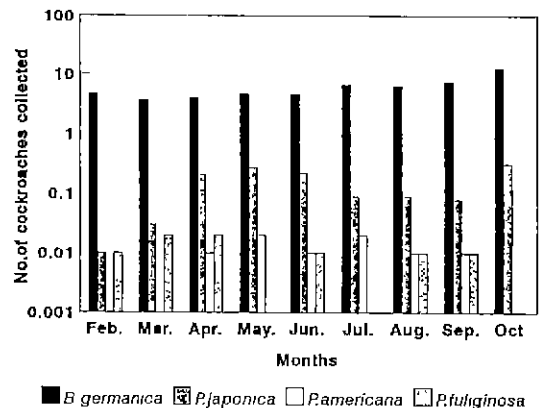


Fig. 3. Relative densities and species composition of cockroaches by month collected by sticky-trap from 7 different habitats in Suwon, Korea, February through October, 1994.

Table 1. The number and percentage of positive traps to the traps-sets from 7 different habitats in Suwon, Korea, February through October, 1994

Month	Hotel-inns		Tea-rooms		Chinese restaurants		Korean restaurants		Hospitals		Apartments		Resident houses		Total	
	Trap set	Positive	Trap set	Positive	Trap set	Positive	Trap set	Positive	Trap set	Positive	Trap set	Positive	Trap set	Positive	Trap set	Positive
Feb.	48.00	8.00	54.00	11.00	54.00	31.00	48.00	5.00	54.00	25.00	54.00	24.00	54.00	24.00	366.00	115.00
(%)		(16.67)		(20.37)		(57.41)		(10.42)		(46.30)		(44.44)		(44.44)		(31.42)
Mar.	48.00	9.00	54.00	14.00	54.00	25.00	48.00	3.00	54.00	25.00	54.00	24.00	54.00	24.00	366.00	129.00
(%)		(18.75)		(25.93)		(46.30)		(6.25)		(46.30)		(44.44)		(44.44)		(35.25)
Apr.	48.00	11.00	54.00	14.00	54.00	36.00	48.00	10.00	54.00	28.00	54.00	26.00	54.00	26.00	366.00	157.00
(%)		(22.92)		(25.93)		(66.67)		(20.83)		(51.85)		(48.15)		(48.15)		(42.90)
May	42.00	16.00	45.00	17.00	45.00	30.00	39.00	11.00	51.00	25.00	45.00	25.00	45.00	25.00	312.00	154.00
(%)		(38.10)		(37.78)		(66.67)		(28.21)		(49.02)		(55.56)		(55.56)		(49.36)
Jun.	48.00	10.00	54.00	22.00	54.00	43.00	48.00	13.00	54.00	37.00	54.00	37.00	54.00	37.00	366.00	201.00
(%)		(20.83)		(40.74)		(79.63)		(27.08)		(68.52)		(68.52)		(68.52)		(54.92)
Jul.	48.00	13.00	54.00	24.00	54.00	45.00	48.00	11.00	54.00	32.00	54.00	29.00	54.00	29.00	366.00	190.00
(%)		(27.08)		(44.44)		(83.33)		(22.92)		(59.26)		(53.70)		(53.70)		(51.91)
Aug.	48.00	11.00	54.00	29.00	54.00	44.00	48.00	6.00	48.00	38.00	54.00	30.00	54.00	30.00	360.00	195.00
(%)		(22.92)		(53.70)		(81.48)		(12.50)		(79.17)		(55.56)		(55.56)		(54.17)
Sep.	48.00	16.00	54.00	30.00	54.00	50.00	48.00	8.00	48.00	35.00	54.00	28.00	54.00	28.00	360.00	206.00
(%)		(33.33)		(55.56)		(92.59)		(16.67)		(72.92)		(51.85)		(51.85)		(57.22)
Oct	24.00	6.00	27.00	13.00	27.00	23.00	24.00	3.00	24.00	13.00	27.00	12.00	27.00	12.00	177.00	88.00
(%)		(25.00)		(48.15)		(85.19)		(12.50)		(54.17)		(44.44)		(44.44)		(49.72)
Total	402.00	100.00	450.00	174.00	450.00	327.00	399.00	70.00	441.00	258.00	450.00	235.00	450.00	235.00	3039.00	1435.00
(%)*		(24.88%)		(38.67%)		(72.67%)		(17.54%)		(58.61%)		(52.22%)		(52.22%)		(47.22%)

*Percentages of positive traps to total of trap sets

Table 2. Densities of 4 species of cockroaches(individuals/trap/week) collected by using sticky-traps from 7 different habitats in Suwon, Korea, February through October, 1994

Species	<i>Blattella germanica</i>				<i>Periplaneta japonica</i>				<i>Periplaneta americana</i>				<i>Periplaneta fuliginosa</i>				Total			
	Month	Egg*	Nymph	Adult	Subtotal	Egg*	Nymph	Adult	Subtotal	Egg*	Nymph	Adult	Subtotal	Egg*	Nymph	Adult	Subtotal	Adult	Subtotal	
Feb.	0.11 (100.00%)	3.34 (99.70%)	1.34 (99.26%)	4.68 (99.36%)	0.00 (0.31%)	0.00 (0.31%)	0.00 (0.31%)	0.00 (0.21%)	0.00 (0.21%)	0.00 (0.31%)	0.00 (0.31%)	0.00 (0.74%)	0.00 (0.21%)	0.00 (0.31%)	0.01 (0.31%)	0.01 (0.74%)	0.02 (0.21%)	0.02 (0.74%)	0.11 (71.30%)	0.11 (100.00%)
Mar.	0.14 (100.00%)	2.57 (99.23%)	1.07 (97.27%)	3.64 (98.92%)	0.00 (0.39%)	0.00 (0.39%)	0.00 (1.82%)	0.03 (0.81%)	0.00 (0.81%)	0.00 (0.39%)	0.00 (0.39%)	0.00 (0.91%)	0.00 (0.54%)	0.00 (0.39%)	0.00 (0.39%)	0.01 (0.91%)	0.01 (0.54%)	0.02 (0.54%)	0.14 (70.19%)	0.14 (100.00%)
Apr.	0.10 (90.91%)	2.79 (98.59%)	1.24 (86.11%)	4.03 (94.38%)	0.01 (0.71%)	0.02 (1.42%)	0.19 (13.19%)	0.21 (4.92%)	0.00 (0.28%)	0.00 (0.28%)	0.01 (0.28%)	0.00 (0.28%)	0.00 (0.28%)	0.00 (0.28%)	0.00 (0.35%)	0.00 (0.35%)	0.00 (0.47%)	0.00 (0.47%)	0.11 (66.28%)	0.11 (100.00%)
May	0.11 (73.33%)	3.45 (98.01%)	1.21 (84.62%)	4.66 (94.34%)	0.03 (20.00%)	0.05 (2.99%)	0.21 (14.69%)	0.26 (5.45%)	0.00 (4.53%)	0.00 (2.99%)	0.00 (7.89%)	0.00 (4.53%)	0.00 (4.53%)	0.00 (4.53%)	0.00 (0.35%)	0.00 (0.35%)	0.00 (0.47%)	0.00 (0.47%)	0.15 (66.28%)	0.15 (100.00%)
Jun.	0.21 (87.50%)	3.24 (97.01%)	1.39 (91.45%)	4.63 (95.27%)	0.03 (12.50%)	0.10 (2.99%)	0.12 (7.89%)	0.22 (4.53%)	0.00 (4.53%)	0.00 (2.99%)	0.00 (7.89%)	0.00 (4.53%)	0.00 (4.53%)	0.00 (4.53%)	0.00 (0.35%)	0.00 (0.35%)	0.00 (0.47%)	0.00 (0.47%)	0.24 (68.72%)	0.24 (100.00%)
Jul.	0.26 (100.00%)	4.54 (97.84%)	2.12 (99.07%)	6.66 (98.23%)	0.00 (1.72%)	0.08 (2.99%)	0.01 (0.47%)	0.09 (1.33%)	0.00 (1.33%)	0.00 (3.85%)	0.01 (0.22%)	0.00 (0.47%)	0.00 (0.29%)	0.00 (0.29%)	0.00 (0.35%)	0.00 (0.35%)	0.00 (0.47%)	0.00 (0.47%)	0.25 (68.44%)	0.25 (100.00%)
Aug.	0.24 (100.00%)	4.09 (97.38%)	2.25 (100.00%)	6.34 (98.14%)	0.00 (2.14%)	0.09 (2.14%)	0.00 (0.47%)	0.09 (1.40%)	0.00 (1.40%)	0.00 (3.85%)	0.00 (0.24%)	0.00 (0.24%)	0.00 (0.16%)	0.00 (0.16%)	0.00 (0.24%)	0.00 (0.24%)	0.00 (0.16%)	0.00 (0.16%)	0.24 (65.12%)	0.24 (100.00%)
Sep.	0.25 (100.00%)	5.22 (98.12%)	2.24 (99.56%)	7.46 (98.68%)	0.00 (1.50%)	0.08 (1.50%)	0.00 (0.47%)	0.08 (1.06%)	0.00 (1.06%)	0.00 (0.19%)	0.00 (0.19%)	0.00 (0.19%)	0.00 (0.19%)	0.00 (0.19%)	0.00 (0.19%)	0.00 (0.19%)	0.00 (0.19%)	0.00 (0.19%)	0.25 (70.37%)	0.25 (100.00%)
Oct.	0.33 (100.00%)	9.36 (96.99%)	3.55 (99.16%)	12.91 (97.58%)	0.00 (3.01%)	0.29 (3.01%)	0.03 (0.84%)	0.32 (2.42%)	0.00 (2.42%)	0.00 (0.35%)	0.00 (0.35%)	0.00 (0.35%)	0.00 (0.35%)	0.00 (0.35%)	0.00 (0.35%)	0.00 (0.35%)	0.00 (0.35%)	0.00 (0.35%)	0.33 (72.94%)	0.33 (100.00%)
Total	1.75 (95.63%)	38.60 (97.84%)	16.41 (96.19%)	55.01 (97.36%)	0.07 (3.83%)	0.73 (1.85%)	0.58 (3.52%)	1.31 (2.35%)	0.05 (0.15%)	0.01 (0.55%)	0.01 (0.12%)	0.01 (0.14%)	0.06 (0.14%)	0.00 (0.14%)	0.00 (0.15%)	0.00 (0.12%)	0.00 (0.14%)	0.00 (0.14%)	1.83 (69.81%)	1.83 (100.00%)
Mean	0.19	4.29	1.82	6.11	0.01	0.08	0.06	0.14	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.20	0.20	

*Number of egg case (ootheca) was not included in the subtotal tabulation in this table)

**Percentages of the monthly total

***Statistical value not available

Table 3. Relative densities of 4 species of cockroaches(individuals/trap/week) collected by using sticky-traps from Chinese restaurants in Suwon, Korea, February through October, 1994

Species	<i>Blattella germanica</i>			<i>Periplaneta japonica</i>			<i>Periplaneta americana</i>			<i>Periplaneta fuliginosa</i>			Total					
	Egg*	Nymph	Adult	Subtotal	Egg*	Nymph	Adult	Subtotal	Egg*	Nymph	Adult	Subtotal	Egg*	Nymph	Adult	Subtotal		
Feb.	0.30	9.91	4.23	14.14	0.00	0.06	0.03	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.30	9.97	4.26	14.23
Mar.	0.19	5.64	2.64	8.28	0.00	0.04	0.14	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.19	5.68	2.78	8.47
Apr	0.19	8.11	4.30	12.41	0.08	0.07	1.08	1.15	0.00	0.02	0.00	0.02	0.00	0.00	0.27	8.20	5.38	13.61
May	0.19	12.62	3.39	16.01	0.06	0.24	0.78	1.02	0.00	0.04	0.01	0.05	0.00	0.00	0.26	12.90	4.18	17.06
Jun.	0.71	12.08	5.20	17.28	0.02	0.48	0.23	0.71	0.01	0.01	0.01	0.02	0.00	0.00	0.73	12.57	5.44	18.01
Jul.	0.88	14.54	7.43	21.97	0.00	0.44	0.04	0.48	0.00	0.00	0.01	0.01	0.00	0.00	0.91	14.98	7.48	22.49
Aug.	0.73	13.70	7.64	21.34	0.00	0.16	0.00	0.16	0.03	0.00	0.06	0.06	0.00	0.00	0.73	13.86	7.70	21.54
Sep.	1.01	15.54	8.73	24.27	0.00	0.20	0.01	0.21	0.00	0.03	0.01	0.04	0.00	0.01	1.01	15.78	8.75	24.49
Oct	1.41	30.59	13.85	44.44	0.00	0.59	0.15	0.74	0.00	0.00	0.00	0.00	0.00	0.00	1.41	31.18	14.00	45.19
Total	5.61	122.73	57.41	180.14	0.16	2.28	2.46	4.74	0.04	0.10	0.10	0.20	0.00	0.01	5.80	125.12	59.97	185.09
(%)**	(96.72)	(98.08)	(95.75)	(97.33)	(2.76)	(1.84)	(4.09)	(2.56)	(0.69)	(0.07)	(0.15)	(0.10)	---	(0.01)	---	(67.61)	(32.30)	(100.00)
Mean	0.62	13.64	6.38	20.02	0.02	0.25	0.27	0.52	0.00	0.01	0.01	0.02	0.00	0.00	0.64	13.90	6.66	20.56

*Number of egg case (ootheca) was not included in the subtotal tabulation in this table

**Percentage represents total average

***Statistical value not available

Table 4. Relative densities of 4 species of cockroaches(individuals/trap/week) collected by using sticky-traps from Korean restaurants in Suwon, Korea, February through October, 1994

Species	<i>Blattella germanica</i>			<i>Periplaneta japonica</i>			<i>Periplaneta americana</i>			<i>Periplaneta fuliginosa</i>			Total				
	Egg*	Nymph	Adult	Subtotal	Egg*	Nymph	Adult	Subtotal	Egg*	Nymph	Adult	Subtotal	Egg*	Nymph	Adult	Subtotal	
Feb.	0.00	0.74	0.31	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74	0.31	1.05
Mar.	0.24	3.93	1.44	5.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	3.93	1.44	5.37
Apr.	0.17	5.75	2.01	7.76	0.01	0.04	0.19	0.23	0.00	0.00	0.00	0.00	0.00	0.18	5.82	2.20	8.02
May	0.22	3.20	1.54	4.74	0.14	0.07	0.62	0.69	0.00	0.00	0.00	0.00	0.00	0.37	3.27	2.16	5.43
Jun	0.29	4.73	1.81	6.54	0.12	0.02	0.30	0.32	0.00	0.00	0.00	0.00	0.00	0.41	4.75	2.11	6.86
Jul.	0.41	8.02	3.32	11.34	0.00	0.07	0.02	0.09	0.00	0.00	0.00	0.00	0.00	0.41	8.09	3.34	11.43
Aug.	0.25	4.84	2.13	6.97	0.00	0.19	0.01	0.20	0.00	0.00	0.00	0.00	0.00	0.25	5.03	2.14	7.17
Sep.	0.23	6.56	2.14	8.70	0.00	0.19	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.23	6.75	2.14	8.89
Oct	0.58	14.46	5.25	19.71	0.00	0.73	0.08	0.81	0.00	0.00	0.00	0.00	0.00	0.58	15.19	5.33	20.52
Total	2.39	52.23	19.95	72.18	0.27	1.31	1.22	2.53	0.00	0.00	0.00	0.00	0.00	2.66	53.57	21.17	74.74
(%)**	(89.85)	(97.39)	(94.23)	(96.51)	(10.15)	(2.55)	(5.72)	(3.45)	—***	—***	—***	—***	(0.06)	(71.71)	(28.29)	(100.00)	
Mean	0.27	5.80	2.22	8.02	0.03	0.15	0.14	0.29	0.00	0.00	0.00	0.00	0.00	0.30	5.95	2.36	8.31

*Number of egg case (ootheca) was not included in the subtotal tabulation in this table

**Percentage represents total average

***Statistical value not available

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/week was found from apartments, tea rooms and resident houses with an average of 5.33, 3.79 and 3.53 individuals of which the number of *B. germanica* constituted 99.52%, 97.13% and 96.32%, respectively (Table 5, 6 and 7); however the species collected from 3 habitats above showed not quite similar, for example, in resident houses from Suwon, of 4 species found *P. japonica* and *P. fuliginosa* were found breeding in range of 1.1-1.5% of the total, which in apartments only 2 species

B. germanica and *P. japonica* were found breeding and the latter species showed with an average of 0.03 individuals (0.48%) per trap/week from apartment (Table 5).

From tea-rooms, 3 species exclusive of *P. americana* were collected, of which the density of *P. japonica* occupies almost 3% of the total cockroaches captured: the number of *P. japonica* characteristically increased in June and October with an average of 0.26 and 0.33 individuals throughout the survey period, respectively (Table 6). A lower relative density and number of cockroaches were observed from hospitals and hotel-inns, resulted in averages of 0.17 and 1.00 individuals per trap/week even though the species composition of above habitats revealed not any particular difference with those of other habitats described previously (Table 8 and 9).

DISCUSSION

Moore and Robinson (1981) studied on the population density of 5 species of cockroaches in the laboratory by using sticky-traps, and reported that the trap use for the relative density could be useful as population density index. As was indicated by Ree, *et al.* (1976), an overall positive trap rate of 47.22% in this study reveals the infestation of cockroach in terms of frequencies was less than that reported by the previous author, however, the higher positive rates were observed in either Chinese or Korean restaurants in range of 60.67-72.67%, and on the contrary lower frequencies of infestation was observed from hospitals and hotel-inns in range of 17.54-24.88%.

During the study period from February to October, 1994, a total of 4 species of cockroaches were

found such as *Blattella germanica*, *Periplaneta japonica*, *P. americana* and *P. fuliginosa*, of which American cockroach (*P. americana*) was recorded for the first time in Suwon after the review of previous cockroach survey records conducted by Cha *et al.* (1969), Shim *et al.* (1973), Ree *et al.* (1973) and Ree (1993).

Among 4 species, *Blattella germanica* was found the predominant species in all 7 different habitats surveyed in Suwon city, the results of which closely coincided with those of Ree, *et al.* (1973, 1993) indicating that *B. germanica* comprised of 99.6% and 99.0% from Seoul and Seoul-Kwangju respectively. It is strongly suggested that the German cockroach (*B. germanica*) should be considered the most important cockroach pest in Suwon as was the cases of Seoul and Kwangju.

Among 7 cockroach breeding habitats surveyed, the highest density was recorded from Chinese and Korean restaurants with averages of 20.56 and 8.31 cockroaches respectively, indicating a particular attention should be paid in suppressing roach population in these habitat area by the Pest Control Division of Suwon Municipal Authority.

As was indicated by Chon and Kwon (1987) in Pusan, the supplies of heating system in the apartments made more favorable breeding environment for the cockroach, in particular, in urban low-income apartments, and the confirmation was made in the study that an intermediate range of cockroach density (5.33 individuals/trap/week) was recorded throughout the survey period from February-October, 1994.

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Table 5. Relative densities of 4 species of cockroaches(individuals/trap/week) collected by using sticky-traps from apartments in Suwon, Korea, February through October, 1994

Species	<i>Blattella germanica</i>			<i>Periplaneta japonica</i>			<i>Periplaneta americana</i>			<i>Periplaneta fuliginosa</i>			Total				
	Egg*	Nymph	Adult	Subtotal	Egg*	Nymph	Adult	Subtotal	Egg*	Nymph	Adult	Subtotal	Egg*	Nymph	Adult	Subtotal	
Feb.	0.21	4.26	2.56	6.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	4.26	2.56	6.82
Mar.	0.27	3.00	1.27	4.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	3.00	1.27	4.27
Apr.	0.09	1.37	0.72	2.09	0.00	0.01	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.09	1.38	0.73	2.11
May	0.14	3.02	1.59	4.61	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.15	3.02	1.62	4.64
Jun.	0.24	2.51	1.23	3.74	0.01	0.04	0.06	0.10	0.00	0.00	0.00	0.00	0.00	0.25	2.55	1.29	3.84
Jul.	0.25	3.58	2.02	5.60	0.00	0.05	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.25	3.63	2.02	5.65
Aug.	0.35	3.47	2.30	5.77	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.35	3.50	2.30	5.80
Sep.	0.19	5.64	1.53	7.17	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.19	5.65	1.53	7.18
Oct.	0.08	5.88	1.75	7.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	5.88	1.75	7.63
Total	1.83	32.72	14.98	47.70	0.01	0.14	0.10	0.24	0.00	0.00	0.00	0.00	0.00	1.85	32.87	15.07	47.94
(%)**	(98.92)	(99.57)	(99.40)	(99.52)	(0.54)	(0.40)	(0.60)	(0.48)	---	---	---	---	---	(68.56)	(31.44)	(100.00)	
Mean	0.20	3.64	1.66	5.30	0.00	0.01	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.21	3.66	1.67	5.33

*Number of egg case (ootheca) was not included in the subtotal tabulation in this table

**Percentage represents total average

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Table 6. Relative densities of 4 species of cockroaches(individuals/trap/week) collected by using sticky-traps from tea-rooms in Suwon, Korea, February through October, 1994

Species	<i>Blattella germanica</i>			<i>Periplaneta japonica</i>			<i>Periplaneta americana</i>			<i>Periplaneta fuliginosa</i>			Total				
	Egg*	Nymph	Adult	Subtotal	Egg*	Nymph	Adult	Subtotal	Egg*	Nymph	Adult	Subtotal	Egg*	Nymph	Adult	Subtotal	
Feb.	0.11	1.29	0.43	1.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	1.29	0.43	1.72
Mar.	0.07	1.30	0.42	1.72	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	1.31	0.42	1.73
Apr.	0.09	0.99	0.39	1.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.99	0.39	1.38
May	0.04	1.40	0.48	1.88	0.02	0.03	0.03	0.06	0.00	0.00	0.00	0.00	0.00	0.07	1.43	0.51	1.94
Jun.	0.05	1.17	0.36	1.53	0.03	0.07	0.19	0.26	0.00	0.00	0.00	0.00	0.00	0.07	1.24	0.55	1.79
Jul.	0.06	1.67	0.55	2.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	1.67	0.55	2.22
Aug	0.05	2.68	1.34	4.02	0.00	0.19	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.05	2.87	1.34	4.21
Sep.	0.11	4.51	1.71	6.22	0.00	0.11	0.00	0.11	0.00	0.00	0.00	0.00	0.01	0.11	4.63	1.71	6.34
Oct.	0.11	10.11	2.37	12.48	0.00	0.33	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.11	10.44	2.37	12.81
Total	0.70	25.12	8.05	33.17	0.05	0.74	0.22	0.96	0.00	0.00	0.00	0.00	0.01	0.75	25.87	8.27	34.14
(%)**	(93.33)	(97.06)	(97.22)	(97.13)	(6.67)	(2.90)	(2.78)	(2.84)	---	---	---	---	(0.03)	(75.77)	(24.23)	(100.00)	
Mean	0.08	2.79	0.89	3.68	0.01	0.08	0.02	0.10	0.00	0.00	0.00	0.00	0.00	0.08	2.87	0.92	3.79

*Number of egg case (ootheca) was not included in the subtotal tabulation in this table

**Percentage represents total average

***Statistical value not available

Table 8. Relative densities of 4 species of cockroaches(individuals/trap/week) collected by using sticky-traps from hospitals in Suwon, Korea, February through October, 1994

Month	<i>Blattella germanica</i>		<i>Periplaneta japonica</i>		<i>Periplaneta americana</i>		<i>Periplaneta fuliginosa</i>		Total						
	Egg*	Nymph	Adult	Subtotal	Egg*	Nymph	Adult	Subtotal	Egg*	Nymph	Adult	Subtotal			
Feb.	0.00	0.34	0.06	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.06	0.40		
Mar.	0.00	0.05	0.04	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.04	0.09		
Apr.	0.00	0.03	0.03	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.06		
May	0.00	0.06	0.05	0.11	0.00	0.02	0.00	0.00	0.00	0.00	0.08	0.05	0.13		
Jun	0.00	0.01	0.02	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.02	0.04	0.06		
Jul.	0.01	0.18	0.02	0.20	0.00	0.00	0.00	0.05	0.00	0.00	0.01	0.23	0.25		
Aug.	0.03	0.09	0.14	0.23	0.00	0.01	0.00	0.00	0.00	0.00	0.03	0.10	0.24		
Sep.	0.00	0.10	0.08	0.18	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.11	0.19		
Oct.	0.00	0.08	0.00	0.08	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.12	0.12		
Total	0.04	0.94	0.44	1.38	0.01	0.10	0.02	0.12	0.00	0.05	0.00	0.05	1.08	0.47	1.55
(%)**	(80.00)	(86.49)	(95.74)	(87.04)	(20.00)	(90.01)	(4.09)	(2.56)	—	(3.09)	—	(68.52)	(29.01)	(100.00)	
Mean	0.00	0.10	0.05	0.15	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.12	0.05	0.17

*Number of egg case (ootheca) was not included in the subtotal tabulation in this table

**Percentage represents total average

***Statistical value not available

Table 9. Relative densities of 4 species of cockroaches(individuals/trap/week) collected by using sticky-traps from hotel-inns in Suwon, Korea, February through October, 1994

Species	<i>Blattella germanica</i>			<i>Periplaneta japonica</i>			<i>Periplaneta americana</i>			<i>Periplaneta fuliginosa</i>			Total			
	Egg*	Nymph	Adult	Subtotal	Egg*	Nymph	Adult	Subtotal	Egg*	Nymph	Adult	Subtotal	Egg*	Nymph	Adult	Subtotal
Feb.	0.00	1.45	0.28	1.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.45	0.28	1.73
Mar.	0.02	0.92	0.24	1.16	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93	0.24	1.17
Apr.	0.01	0.53	0.09	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.09	0.62
May	0.02	1.04	0.50	1.54	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	1.04	0.51	1.55
Jun.	0.01	0.34	0.15	0.49	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.15	0.51
Jul.	0.05	0.65	0.42	1.07	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.42	1.09
Aug.	0.07	0.55	0.26	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.26	0.81
Sep	0.02	0.50	0.18	0.68	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.52	0.18	0.70
Oct.	0.04	0.50	0.33	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.33	0.83
Total	0.25	6.48	2.45	8.93	0.00	0.06	0.01	0.07	0.00	0.00	0.00	0.00	0.01	6.55	2.46	9.01
(%)**	(100.00)	(98.78)	(99.59)	(99.00)	---	(0.92)	(0.41)	(7.77)	---	---	---	---	(0.15)	(72.70)	(27.30)	(100.00)
Mean	0.03	0.72	0.27	0.99	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.73	0.27	1.00

*Number of egg case (ootheca) was not included in the subtotal tabulation in this table

**Percentage represents total average

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