COCKROACH INSECTICIDE TREATMENTS AND HUMAN LIFESTYLES IN COUNCIL FLATS IN FRANCE

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Abstract—The current situation concerning cockroach (*Blattella germanica* (L.)) presence and insecticide control was investigated in high-rise blocks of low-income flats in the French city of Rennes. The aim of this study was to analyse the results of professional cockroach insecticide treatments and to try to understand why control success was so low. Treatments were proposed every two months for a year. Cockroach abundance and six general environmental characteristics were recorded after each treatment, for each flat treated. The environmental characteristics recorded for each flat were : nationality of residents, duration of occupation, human density, application of domestic pesticides, reactions of residents to the presence of cockroaches and degree of cleanness. A multivariate analysis stressed the influence of the combination of level of cleanness and human density on cockroach abundance. Our data revealed for the first time that although dirtiness influenced cockroach abundance it did not influence cockroach presence. Residents' nationality, duration of occupation, reaction to the presence of cockroaches, use of domestic insecticides were not correlated with cockroach presence or abundance. Our data show that the part played by the residents in a given structure has been greatly underestimated so far when the results of treatments are analysed.

INTRODUCTION

According to agricultural standards, the objective of insecticide use is to reduce pest infestations to below the level at which they cause damage, as effectively and as economically as possible (Dent, 1991). However, in urban environments, the ideal level is often zero individuals. Urban pests are organisms damaging human interests (Bennett and Owens, 1986). Subjectively, one of the main urban pests is the cockroach, although cockroaches rarely cause important economical damage. However, cockroaches can be health hazards (Roth and Willis, 1957; Burgess, 1984; Cochran, 1982; Bennett and Owens, 1986; Le Guyader *et al.*, 1989; Cloarec *et al.*, 1992; Rivault *et al.*, 1993).

Cockroach pest species are successful in exploiting the resources human structures and life styles offer. Humans shape the urban ecosystem which provides all the necessary resources (food, water, harborage, temperature and humidity) for cockroaches, in an environment where they do not have any predators other than human beings (Bennett and Owens, 1986; Rivault *et al.*, 1994).

This makes control, or management of these organisms, described as pests, an important challenge. However, cockroach control, relying solely on pesticide use, is often a failure for many reasons. One of them is insecticide resistance. This major biological problem is very well documented for feral populations in the USA. However, there are no data for French cockroach populations. In France, pesticide use in council housing is generally limited to one professional treatment per year, sometimes even less. This does not mean that resistance does not exist in these populations.

The aim of our study was to analyse the results of controlled series of professional insecticide treatments on feral cockroach populations in council flats in multi-family buildings in the town of Rennnes, France, and to try to understand why treatments failed.

MATERIAL AND METHODS

Study Buildings

Three blocks of council flats (named A, B and C) with comparable high cockroach infestation levels were chosen after preliminary investigations. These blocks were built in the city of Rennes (France) in the 1970's. These 15-storey, 96-flat buildings all had 6 flats on each floor.

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Insecticide Treatment

A different type of insecticide, chosen among the three main groups of insecticides commonly used, was applied in each building. Propoxur was used in building A, deltamethrine in building B, propetamphos in building C. Formulations dissolved in water were preferred for spraying the flats. Applications were done by professional pest control agents working for the city of Rennes under our control. We proposed a free treatment every 2 months for a year, i.e. there were 7 treatments.

Before the first treatment all the residents were informed that their building had been chosen for a special cockroach control programme and that their cooperation was requested. Our aim was to treat as many flats as possible during this first treatment to get a picture as precise as possible of the cockroach situation and to evaluate as exactly as possible the quantity and distribution of cockroaches in each building and in each flat. 71% to 82% of the flats in a building were treated during this first treatment. During the first treatment we aimed at treating the kitchen, the hall cupboard with the hot water pipes, the bathroom and the toilet in all the flats.

Before the subsequent treatments we asked, in each flat, if any of the residents had seen any cockroaches since the previous treatment, and if so, we offered to treat the flat again. The residents were free to accept or refuse any treatment. We elaborated a flexible protocol that aimed at reducing constraints on residents as much as possible and let them intervene in the control of their own flat.

Data collecting

Several environmental characteristics of each flat as well as the number of dead cockroaches following a treatment were recorded.

Five different levels of cockroach abundance were noted:

Level 1 : flat was treated, but we did not see any cockroaches.
Level 2 : flat was treated, but we only saw a few individuals, i.e. less than 10 cockroaches, (developmental stage was not taken into account).
Level 3 : flat was treated, the cockroach population was well established (between 10 and 50 individuals).
Level 4 : flat was treated, cockroaches were pullulating (over 50 individuals).
Level 5 : flat was not treated.

General environmental characteristics recorded for each flat were:

- Building (A, B or C), storey and flat number.
- Nationality of residents (N1 = French, N2 = foreigners).
- Duration of occupation of flat (O1 = 0–2 years, O2 = 3–10 years, O3 = >10 years occupancy).
- Human density (number of residents 100 / m^2 in the flat) (F1 = 1–3 people /100 m^2, F2 = 4–6 people / 100 m^2, F3 = 7–9 people / 100 m^2, F4 = 10–13 people / 100 m^2).
- Self-reported application of domestic pesticides (I1 = none, I2 = cannot remember the trade mark and casual use, I3 = know the trade mark and frequent use).
- Reactions of residents to the presence of cockroaches (P1 = indifferent, P2 = frightened, horrified or disgusted, P3 = no reply, P4 = never seen or had any cockroaches, P5 = cockroaches are dirty, unhygienic, P6 = neighbours are responsible for their presence, P7 = they cause damage or prejudice).
- Degree of cleanness (S1 = clean and tidy, S2 = average, S3 = dirty and cluttered).

Principal Component Analysis with Respect to Instrumental Variables (PCAIV)

Multidimensional methods reveal the main tendencies of a complex set of data, which can then be classified and yield synthetic graphic representations (Benzecri, 1973). PCAIV analysis (Biomeco software, Lebreton *et al.*, 1990) aims at explaining one set of information (level of cockroach abundance in the flats) by another set of information (environmental characteristics in these same flats). With this method we tried to explain the presence-absence of cockroaches in relation to

environmental conditions that, here, were represented by characteristics of residents and of their flats, and to reveal a typology of the flats and their residents.

RESULTS

50 flats were never treated because those residents always refused a treatment and did not let us in. These 50 flats were not included in our data analyses because we could estimate neither the environmental factors nor cockroach abundance related to these flats.

The other 232 flats were all treated at least once. 452 insecticide treatments were applied during 7 sessions.

The PCAIV enables to analyse the results of this insecticide control campaign and to relate the cockroach abundance data (Fig. 1) to the environmental data (Fig. 2) on the same factorial plane defined by axes 1 and 2 (Rivault and Cloarec, 1995).

Interpretation of the Axes of the PCAIV

On the graphical display of the cockroach abundance data the first axis can be interpreted as the presence-absence of cockroaches; this axis separates flats according to the level of cockroach abundance (Fig. 1, Table 1). The second axis is difficult to interpret in terms of cockroach abundance.

On the graphical display of the environmental factors data, several factors contribute to the first axis: human density, building and cleanness (Fig. 2, Table 1). The second axis can be interpreted as a cleanness axis.

Axes 1 and 2 are orthogonal. That means that the variables represented on these two axes are independent. Therefore, the variable cockroach presence represented on axis 1 of the first data set

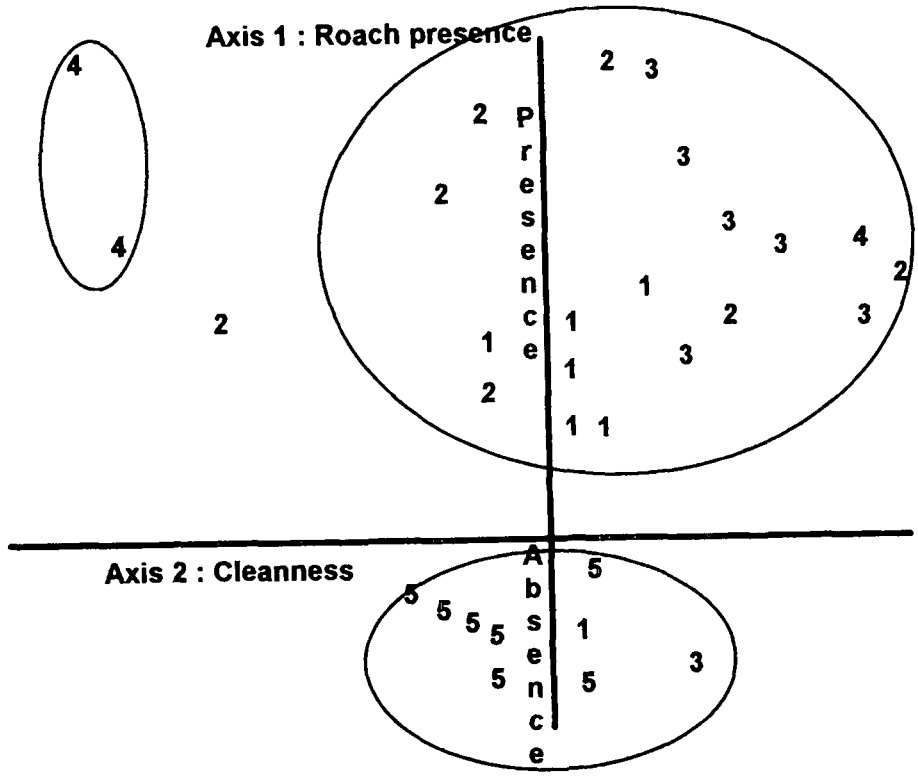

Figure 1. Cockroach abundance. Projection of the cockroach abundance data on the plane defined by axes 1 and 2 of PCAIV. This graph represents the centres of gravity of the data points for the 5 levels of cockroach abundance for each treatment (5 × 7 = 35 points). The ovals materialize the 3 categories of flats described in the text.

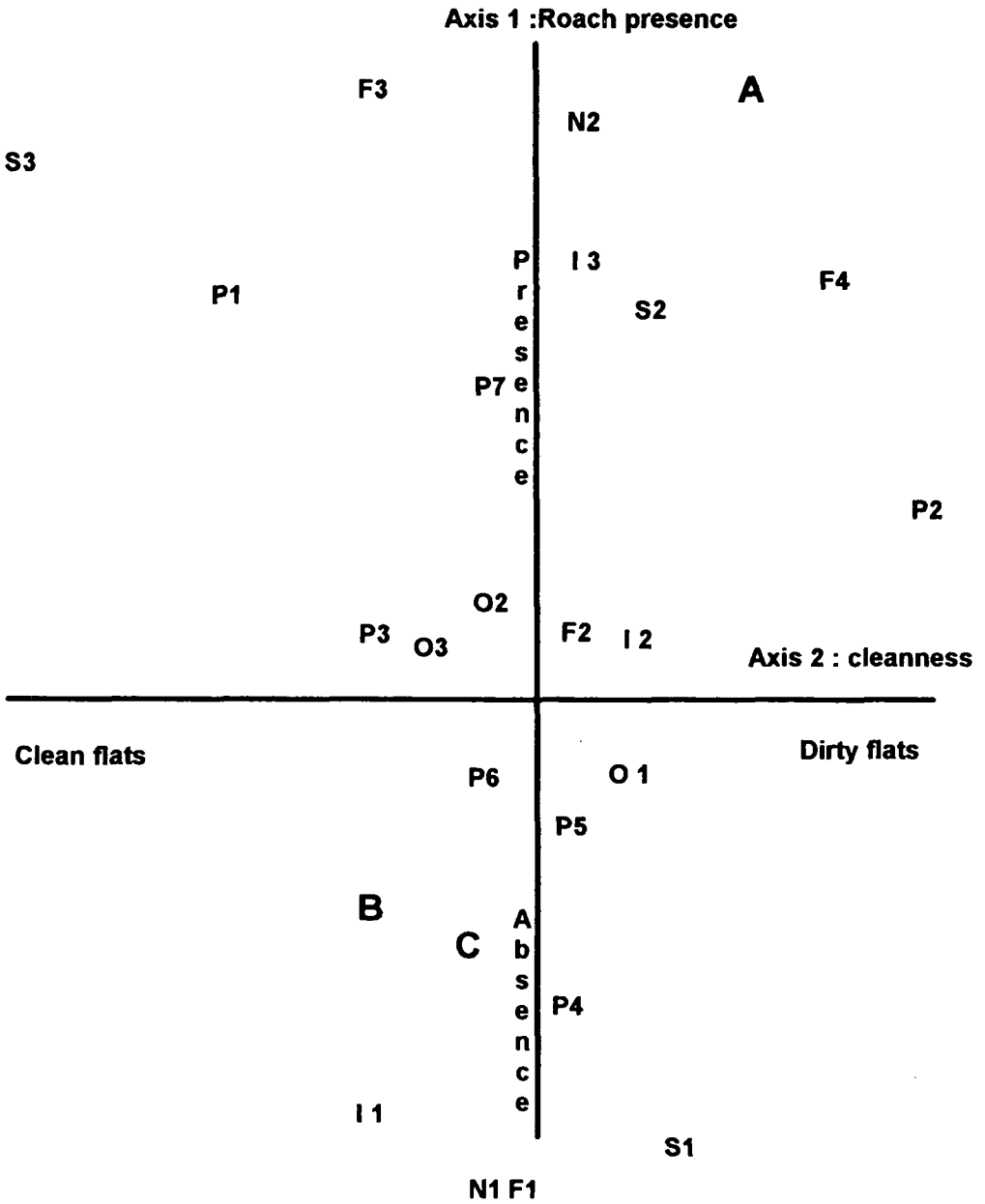

Figure 2. Environmental factors. Projection on plane defined by axes 1 and 2 of PCAIV of data points for the different categories of the 6 environmental factors recorded. See material and methods for details of abbreviations.

Table 1. Contribution of the different environmental factors on the 2 main axes of the PCAIV for the three buildings

	Axis 1	Axis 2
Building	**0.31**	0.061
Nationality	0.25	0.003
Occupation	0.009	0.02
Human density	**0.40**	0.13
Use of insecticide	0.14	0.04
Reaction to cockroaches	0.25	0.17
Cleanness	**0.28**	**0.51**

varies independently of the variable cleanness represented on axis 2 of the second data set. In other words the presence-absence of cockroaches in a flat is not related to the cleanness of that flat.

Different types of flats

The graphical representation of the analysis allowed us to separate the flats into 3 categories (Fig. 2) :

(1) The first category included clean (S1) flats with low human densities (F1) and with French residents (N1), who did not use any insecticides (I1) and who said that they had never had or seen any cockroaches in their flat (P4). We never found any cockroaches in these flats (cockroach abundance level 5).

(2) The second category of flats included flats of average cleanness (S2) with high human densities (F3 and F4), often with foreign residents (N2) who used insecticides (I3) and who either said that they were horrified or frightened of cockroaches (P2) or complained about the damage caused by cockroaches (P7). We recorded low or medium densities of cockroaches (levels 1, 2 and 3) in these flats.

(3) The third category of flats included dirty and cluttered flats (S3) with high human densities (F3) and the presence of cockroaches left the residents indifferent (P1). Nationality was not an important factor. We recorded high cockroach densities in these flats (level 4). However, there were very few flats of this category.

Environmental factors

Environmental factors analyzed one by one in relation to the cockroach density levels and their contribution to the two first axes of the analysis can be divided into two categories (Fig. 1 and 2, Table 1).

Factors unrelated to cockroach abundance

Duration of Occupation. The contribution of this factor to the first two axes is very low. This means that duration of occupation was not related to cockroach abundance. The distribution of cockroaches cannot therefore be explained by changes in tenancies. This does not support the wide spread idea that cockroach infestations are due to moving home frequently.

Use of Domestic Insecticides. No use of domestic insecticide (I1) is associated with flats without cockroaches and important use of insecticide (I3) is associated with flats with cockroaches. This factor has a low contribution to the first two axes. The use of domestic insecticides implies the presence of cockroaches, even though this use has little or no effect on the density of cockroach populations. On the other hand, when there are no cockroaches, residents do not use cockroach insecticide.

Reactions of residents to the presence of cockroaches in their flat. Indifference to the presence of cockroaches (P4) is associated with high cockroach densities (level 4). Fright (P2) and prejudice (P7) are associated with low cockroach densities. The reply "never seen or had any cockroaches in their flat" (P4) is associated with flats without cockroaches. The projection points for the reactions "cockroaches raise hygiene problems" (P5) or "neighbours are responsible for their presence" (P6) are near the centre of gravity of axes 1 and 2. These two parameters are not related to the presence-absence of cockroaches, but reflect more prevailing opinion.

Nationality. This factor is strongly linked to human density because French families are usually smaller than foreign ones. Small flats were occupied by single people of French nationality. On average, low human densities are linked with French tenants and high human densities with foreign families. But the few large French families in these buildings also had high cockroach densities.

Factors related to cockroach abundance

Human Density. This factor is the factor which contributes the most to the first axis. The link between human density and level of cockroach abundance, can be explained by the fact that there

were many things (furniture as well as smaller objects) on the floors and on or against the walls in these flats. An increase in the amount of objects in the flat, thereby decreasing free floor-space and wall-space, plays an important part in the control of cockroach populations by providing an increased number of available shelters for cockroaches and by impairing the efficiency of professional treatments.

Cleanness. This is the factor that contributes the most to axis 2 and opposes very dirty flats (S3) to average (S2) and clean (S1) flats. A dirty flat will not necessarily harbour cockroaches and a very clean flat will not always be without any cockroaches. However, medium scores of cockroach densities (level 3) are linked with average cleanness scores, and high cockroach densities (level 4) are linked with scores for dirty flats (S3).

The absence of cleanness encourages cockroach pullulation but plays no part in their presence-absence, thus confirming the indications given by the interpretation of the axes.

Building. Building A was opposed to the other 2 buildings on axis 1 by a higher level of cockroach infestation. Although the three buildings were architecturally similar, building A housed people with lower incomes.

DISCUSSION

This one-year series of treatments proposed every two months, did not improve the situation as greatly as expected.

The multivariate PCAIV analysis of our data indicated that the presence or the absence of cockroaches in flats can be explained at least partly by some environmental factors like human density in the flat, building effect and cleanness. But none of the environmental factors which we recorded appear to be able to explain, alone, either the presence of cockroaches, or the size of the cockroach populations. This problem is complex and undoubtly multifactorial. Human density is an indirect way of measuring free ground and free wall space in a flat, particularly in the kitchen where cockroaches are generally found. Cockroaches find more potential undisturbed shelters in cluttered flats. The more shelters there are, the more widely cockroaches are distributed all over the flat (Rivault, 1989; 1990). The presence-absence of cockroaches in a flat is not related to the cleanness of that flat. However, the absence of cleanness encourages the development in size of cockroach populations because food resources become more dispersed throughout the flat. Shorter distances between shelter and food make access to food easier and facilitate survival and growth of young larvae (Rivault and Cloarec, 1990; 1991) and female reproduction (Cochran, 1983).

After one year, some flats still had high cockroach densities that we had been unable to reduce by applying our protocol. This can be explained by several reasons:

According to their feelings, cultural background and their upbringing, residents were unable to record cockroach presence correctly in their own flat. Sawyer and Casagrande (1983) already stressed the importance of human factors in the control of pest populations and stated that responses to arthropods can be conditioned by many factors such as cultural and educational background, available information, personal sensibility, preferences and values.

The French law on private liberty allows residents to refuse access to their flat to anybody, including council administrators. In spite of all our attempts, we had great difficulty in contacting all the tenants. In the 3 buildings, the proportion of flats we were never able to visit was relatively high (50/282, i.e. approximately 17 %). When cockroach densities reach very high levels, highly infested flats play the part of a population reservoir for neighboring flats, they become a source of migrant animals especially when maximum capacity of the initial occupation zone has been reached (Rivault, 1992). The available insecticides would be efficient for reducing these level 4 density cockroach populations to at least level 2 or 3 densities, as long as these flats could be treated.

The usual reasons evoked to explain pest control failures such as cockroach insecticide resistance and inefficiency of treatments all influence the result, but our data clearly reveal for the first time that the part played by the residents has been greatly underestimated so far when the results of treatments are analysed. Here we show that under similar treatment conditions such as we applied in our protocol, the results for each flat depend largely on the residents' attitude.

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REFERENCES

Bennett, G.W., and Owens, J.M. (Editors) (1986). Advances in urban pest management. Van Nostrand Reinhold Company, New-York, 398 pp.

Benzecri, J.P. (1973). L'analyse des données. II. L'analyse des correspondances. Dunod, Paris, 619 pp.

Burgess, N.R.H. (1984). Hospital design and cockroach control. *Trans. R. Soc. Trop. Med. Hyg.*, 78: 293–294.

Cloarec, A., Rivault, C., Fontaine, F., and Le Guyader, A. (1992). Cockroaches as carriers of bacteria in multi-family dwellings. *Epidem. Inf.*, 109: 483–490.

Cochran, D.G. (1982). Cockroaches - biology and control. *Who, vector biology and control series*, Geneva, Switzerland, 856: 1–53.

Cochran, D.G. (1983). Food and water consumption during the reproductive cycle of female german cockroaches. *Entomol. Exp. Appl.*, 34: 51–57.

Dent, D. (Editor), (1991). Insect pest management. C.A.B. International, Wallingford, 604 pp.

Lebreton, J.D., Roux, M., Bacou, A.M., and Banco, G. (1990). Bioméco (Biométrie-Ecologie), version 3.9, software of statistical Ecology for PC.

Le Guyader, A., Rivault, C., and Chaperon, J. (1989). Microbial organisms carried by brown-banded cockroaches in relation to their spatial distribution in a hospital. *Epidem. Inf.*, 102: 485–492.

Rivault, C. (1989). Spatial distribution of the cockroach, *Blattella germanica*, in a swimming-bath facility. *Entomol. Exp. Appl.*, 53: 247–255.

Rivault, C. (1990). Distribution dynamics of *Blattella germanica* in a closed urban environment. *Entomol. Exp. Appl.*, 57: 85–91.

Rivault, C. (1992). Invasion des milieux urbains par les blattes: exemple de la ville de Rennes. In: J.M. Legay (Editor), *Actes du colloque national d'écologie urbaine*, Mions (Rhône)

Rivault, C., and Cloarec, A. (1990). Food stealing in cockroaches. *J. Ethol.*, 8: 53–59.

Rivault, C., and Cloarec, A. (1991). Exploitation of food resources by the cockroach *Blattella germanica* in an urban habitat. *Entomol. Exp. Appl.*, 61: 149–158.

Rivault C., and Cloarec, A. (1995). Limits of insecticide cockroach control in council flats in France. *J. Environ. Manage.*, 45: 379–393.

Rivault, C., Cloarec, A., and Le Guyader, A. (1993). Bacterial contamination of food by cockroaches. *J. Environ. Health*, 55: 21–22.

Rivault, C., Cloarec, A., Mathieu, N., and Blanc, N. (1994). Les blattes, un animal de ville à toutes saisons. *Les Annales de la Recherche Urbaine*, 61: 33–38.

Roth, L.M., and Willis, E.R. (1957). The medical and veterinary importance of cockroaches. *Smithson Misc. Coll.*, 134: 1–147.

Sawyer, A.J., and Casagrande, R.A. (1983). Urban pest Management: a conceptual framework. *Urban Ecol.*, 7: 145–157.