Proceedings of the Sixth International Conference on Urban Pests
William H Robinson and Dániel Bajomi (editors), 2008
Printed by OOK-Press Kft., H-8200 Veszprém, Pápai út 37/a, Hungary

CONTROL OF RODENTS WITH RODENTICIDES

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Abstract For the development of a methodology for the population management of brown rats, taking into consideration seasonal population dynamics in space and in time, as well as changes in the age composition of the population, two experiments were held. One of them was conducted in the rice fields of the Krasnodar region of Russia, from December 1981 through October 1982; the other was conducted in the factories of the KAMAZ company, during the period from January to October of 1991. As practice has shown, the total eradication of targeted (problem) animal species is hardly possible. Aside from that, such an approach is subject to criticism, based on ecological, bioethical, religious, and ethnic considerations, among others. In its place, a conceptual plan is suggested for the creation of limited control zones surrounding the most critical facilities and territories.
Key Words Deratization, population dynamics, intrapopulation diversity

INTRODUCTION

Deratization is an integral part of that system for the struggle with living organisms that pose a threat to humans–that is, with targeted (problem) species, which is called "pest control," and, more recently, "population management of problem animal species" (pest management) (Bibikov et al., 1987; Prakash, 1988; Singleton et al., 1999; Shchipanov, 2002; Rylnikov, 2005; Shilova, 2005). The goal of pest management is the reduction of the number of targeted species of rodents in a given territory of a known surface area, which may be achieved by restricting factors contributing to population growth: reproduction (B) and immigration (I), as well as factors contributing to population reduction: mortality (D) and emigration (E).

Limiting the rate of reproduction may be considered one of the most promising methods for affecting the population dynamics of the targeted species of rodents–with the exception of the use of chemosterilants, which have been rejected by the international community (Shilova, 1993; Shchipanov, 2002). This method is also one of the environmentally safest. At the same time, it must be acknowledged that there are currently no prospects for putting the methods and means for controlling the fertility of the animals into wide practice. A. Buckley (1999) believes that a long time still remains until the day when the use of rodenticides will be halted. They remain an important component of rodent population control. Taking into consideration the author's own experience in the study of the brown rat, it is precisely this species that has been taken as the model target species, for the development of a methodology for the management of its population by way of increasing the forced component of its mortality.

MATERIALS AND METHODS

For the development of a methodology for the population management of brown rats, taking into consideration seasonal population dynamics in space and in time, as well as changes in the age composition of the population, two experiments were held. One of them was conducted in the rice fields of the Krasnodar region of Russia, from December 1981 through October 1982 (Rylnikov, 2006a); the other was conducted in the factories of the KAMAZ company, during the period from January to October of 1991 (Rylnikov, 2006 b).

Rice Fields

Records were kept based on the number of active burrows within the surface area of 175 hectares where the extermination measures were taken. On this piece of land, during the winter period, the rats were concentrated in unplowed plots, and in those places where large amounts of unthreshed hay remained. This facilitated the localization of the place in which the extermination measures were carried out. The density of brown rats on this plot was 32 active burrows per 100 m straight-line measurement. On the control territories, with a surface area of 75 hectares, the burrow density proved significantly lower, an average of 6 live burrows per 100 m straight-line measurement. There is no reproduction during this period, and the population of the animals decreases, due to natural mortality, by3 to 3.5 times during the period from November through April. The rate at which the control bait was consumed (rice-based, with 10% sugar and a tetracycline marker) was high, as witnessed by the high percentage (86%) of marked brown rats. Meanwhile, the rate at which the rice with tetracycline was eaten in June was lower, as a result of which a percentage of only 44% of marked rats was obtained. Such a discrepancy in the rate of consumption of the control bait is connected, first of all, with the insufficient supply of food in the winter period, and, secondly, with the absence in the population of offspring, whose presence increases the population's diversity, and leads, as a result, to an increase in its resistance to harmful influences (Rylnikov, and Karaseva**,** 1985; Rylnikov, 2007). To increase resistance to weather conditions, 50-gram paraffin-lined blocks were used, which, moreover, proved the least attractive for birds. In various periods of winter and spring, paraffin-lined blocks were used with 6% zinc phosphide , blocks with 0.5% fluoride acetamide, and blocks with 0.03% diphacinone. Extermination measures were carried out in 3 stages. During the 2nd and 3rd stages, the bait was laid not across the entire surface area of the experimental area, but only on those rice plots where the number of rats remained highest.

Factories

The KAMAZ auto factories are scattered around the populated area of the city and are separated from it by broad, kilometer-wide sanitary zones. Tracking platforms were acknowledged as the basic means of record-keeping, and, in addition, we applied traps, primarily in order to capture animals with the goal of then dissecting them and evaluating the condition of the population. In places with increased ventilation, and with increased ground humidity, the following method of simultaneous counting and extermination of rats proved to be the most advantageous: to a solid surface of laminated cardboard, we applied a layer of vaseline-based paste, talc (1:1), and 0.5% warfarin or 0.2% triphenacine (a mixture of diphacinone and ethilphacinone), on top of which we sprinkled whole oats, moistened with 3% vegetable oil. The rats, when taking the grain from the paste, created empty spaces on the surface of the sheet and, in so doing, revealed their presence.

RESULTS

Rice Fields

As a result of the extermination procedures against the rats, repeated three times during the period from December through June, on a test plot of rice fields with a surface area of 175 hectares, their numbers (32 burrows per 100 m straight-line measurement) decreased by 23 times, and that not only in the test plots, but also on neighboring plots, as indicated by the finding of only isolated active burrow entrances (1.5 burrows per 100 m straight-line measurement). Moreover, on the control plots, the population of rats (6 burrows per 100 m straight-line measurement) was also reduced, but only by 3 times (to 2.2 burrows per 100 m straight-line measurement). Thanks to the high mobility of brown rats in rice fields during the winter (Rylnikov and Karaseva, 1985), apparently, the bait with the rodenticide was also eaten by rats from surrounding plots, where the rat population also declined proportionately. These data were obtained despite the fact of the spring/summer period, a time of a general rise in rat population, due to more active reproduction. By October, the reproduction of brown rats in the southern latitudes decreases, and cannot be the cause of a restoration of population levels. The plots of the rice fields treated with rodenticides were, by fall, carefully plowed over, all the remains following the threshing of grain were removed, as a result of which they were not very attractive for immigrants. The year in which the fields were treated was the year in which brown rat numbers began to fall in the rice fields, this is one of the reasons for the low rate of population restoration on this plot. By October of the same year, the density of inhabited entry openings to the burrows was no higher than 0.7 per 100 meter straight line. On the territory, following the treatment with rodenticide, migrants were scattered, unfamiliar with the territory, and were experiencing stress; in order to restore full reproductive activity, these animals require the restoration of a normal population structure (Shilova and Orlenev, 2004). In this fashion, the extermination measures, carried out successfully in the winter/spring period, ensured a low population level of rats in the rice fields during the summer period.

The required difference equation, which reflects the restoration of the rat population on the plot after the extermination measures were carried out, may look like the following:

$$(x_0\ (t+\Delta t) - x_0(\Delta t))/\Delta t = r_0(x_0\ (t)) \times x_0\ (t) + \Delta x'/\Delta t$$

where $r_0(x_0\ (t))$ is the specific speed of population growth due to the difference between birth rate and death rate, which depends on population density $x_0(t)$. The volume of exchange of migrants among connected plots may be expressed by the quantity $I_0 - E_0 = \Delta x'/\Delta t$. All necessary parameters for the equation were obtained by observing the changes in rodent population on a constant plot over the course of a sufficiently long time period, by mapping the territory and registering all changes in rodent density at various points on the territory of the given plot, and by studying the range and intensity of rodent migration on this plot (Rylnikov, 2007).

Factories

The number of points where rats were detected in a particular unit of space was not large, and, moreover, during the course of measurements, it became clear that, with the help of the tracking platform, rats were detected 6 times more often than with traps, and, on top of that, the platforms were more convenient to work with; they were easier to position and to locate in cases of repeated investigations. The presence of rats was detected only in one case per 5,000 m^2, which confirmed our estimate concerning the insufficiently abundant food base for growth in numbers of the rat population. Most often, we found the combination of these conditions in technical spaces: lavatories, areas of human food consumption, and places where personnel were constantly present, which comprised no more than 2% of the overall area of one of the factories (400 thousand m^2). The workshop, with constantly working mechanisms, personnel who continually changed positions, active transport docking–that is, the majority of the territory of the factories–does not attract rats, but, at the same time, is not avoided by them. At this factory, the effectiveness of deratization by the application of rodenticides only on areas inhabited by rats (2%), for the period from January through June, was 84%. Until the autumn of the current year, the numbers of brown rats at the factory remained approximately at the level of the numbers for June, although, in the third quarter, there were no repeated treatments of the facility. This is apparently connected with the fact that the reproductive potential of the rat population proved insufficient during the remaining two months of the breeding period. By October, the reproduction of brown rats in the central belt of the Russian Federation, as a rule, ends, and could not have been the cause of a restoration of their numbers. The immigration component of the restoration of rat numbers, as in the first case, was not high, because of the absence of rats on the territory of the factory yard, and the significant distance to the nearest factories of the company (up to 1,000 meters).

DISCUSSION

As practice has shown, the total eradication of targeted (problem) animal species is hardly possible. Aside from that, such an approach is subject to criticism, based on ecological, bioethical (Shilova, 2001; Shilova, 2005), religious, and ethnic (Lapshov and Inapogi, 1993) considerations, among others. In its place, a conceptual plan is suggested for the creation of limited control zones surrounding the most critical facilities and territories (Rylnikov, 2005). The rational alteration of the environment in biocenoses is considered, in many countries of the world, to be the most effective and environmentally safest method for controlling the numbers of targeted (problem) rodents (Davis, 1977; Colvin and Jackson, 1999; Shilova, 2001; Shilova, 2005).

In order to achieve an acceptable population level, specialists in rodent population management are compelled to work within limited confines of space and time, and at a particular stage in the population cycle; this must be taken into consideration when putting together correct strategies and tactics for the population control of brown rats and other species of rodents (Naumov, 1971; Davis, 1977). One must take into account the necessity of choosing a calendar period during which the rodent population is most sensitive to those methods that harm it, including methods of deratization. One such period is the period of diapause in the reproductive cycle–for example, late autumn, winter, and early spring, when the intensity of brown rat breeding decreases in most of their populated territory, situated in the northern and central latitudes and, in part, in southern latitudes. The proportion of impuberal animals drops; animals of older age groups predominate (Farhang-Azad and Southwick, 1979; Rylnikov, 1992), and the variety of rodent population, according to phenotypical indicators, is the poorest [Schwarz, 1980]. In the fall/winter and early spring periods, the territory occupied by the population is contracted; rodents, especially synanthropic rodents, are compactly confined to places with a stable food base and a conducive microclimate (in cities, to buildings and garbage dumps; in the open stations of southern latitudes, to non-freezing bodies of water and to fields with the remains of grain cultures).

As a result of a greater homogeneity of age composition, and the predomination of adults over young, one can expect that in the winter period of the year the cull resulting from the effects of rodenticides will be less selective than in the spring and summer periods, the time of the mass appearance of young.

In the fall period, temporary rodent settlements may be formed, due primarily to resettlement by the young. The low population numbers, the high proportion of migrants, who are less careful regarding means of extermination and other new objects [Gibson, 1982], and the homogeneous age composition (for example, the predominance of the young over the adults) increases the probability that the animals will perish in temporary settlements, in “transfer stations” (Shilov, 1977). It is known that primitive biological systems prove to be more vulnerable to external factors of influence than more complex structures.

Less successful extermination measures can be carried out in the period of activization of the reproductive cycle–for example, in spring and summer. The reason for this is the abundance of food, which makes the bait less attractive; among the population are pregnant and nursing females and impuberal young, who are highly selective regarding the choice of food and resistant to indirectly-acting blood anticoagulants (Rylnikov and Zvonarev, 1986). A portion of the brown rat population proves to be outside the boundaries of the zone of application of the means of regulation of their numbers; first of all, a large number of suckling young lives in nests, apart from the areas of rodenticide application; secondly, due to spring/summer migrations from man-made structures to open stations (Karaseva et al, 1986), there occurs an expansion of the borders of the brown rat population.

The spatial and temporal sub-population units, in different seasons of the year, will possess qualitative characteristics that fundamentally distinguish them from one another with regard to the resistance of the problem species to the effects of rodenticide. Above all, this will be determined by the varying age and phenotypic composition of the groupings, and the hormonal status of both males and females, which apparently determines the level of their resistance and avoidance reaction with respect to rodenticides.

CONCLUSION

The study of the dynamics of spatial and temporal sub-population units, peculiarities of movement, nourishment, and differences in age, sexual, and phenotypic qualities, forms the basis for the development of strategies and tactics for managing the numbers of this population on the territory of a populated locality, a free-standing building, structure, yard territory, or plot of agrocenosis.

The strategy for deratization consists in the control of population numbers of brown rats, taking into account dynamics over the course of the calendar year, the spatial structure, reproduction, age composition, mortality, seasonal migrations on the territory of the agricultural complex (of the populated locality, in open stations that are of the same type in terms of the character of conditions, for example, the sowing of cultivated plants) during the fall/winter period with the greatest vulnerability to harmful effects; the greatest natural and forced mortality, with the greatest patchiness in terms of spatial distribution. A part of this plan is the order of liberation not only of the entire territory occupied by the population, but also of separate facilities, and the long-term (over the course of the entire calendar year) prediction of the restoration of the pest population in them.

The tactics for deratization amount to the following: a) the reduction of the size of the area of habitation, which determines the speed of restoration of the population numbers, and its maximum level; b) the reduction of the numbers of brown rats, on the given territory in the given calendar period, to an acceptable level, by increasing the forced component of mortality, while at the same time reducing their birth rate (when the appropriate means are available), the limitation of immigration streams, and the reduction of the number of immigrants that successfully take root, through measures of the physical defense of buildings and territory, and also by applying long-acting means of capture and extermination; c) the implementation of a short-term (over the course of a period of up to half a year) prediction of the reduction and restoration of population numbers of brown rats on the territory being treated; d) the implementation of a prediction of the development of adaptations of individuals in the population to the methods for the extermination of brown rats, and overcoming these adaptations by rotating the means and the technologies of their application.

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