ACTA THERIOLOGICA
Vol. 34, 24: 339—346, 1989

The Time of Oat Starch Remaining in the Digestive Tract of Rodents

Joanna BABIŃSKA-WERKA & Dariusz MATYJA

Babińska-Werka J. & Matyja D., 1989: The time of oat starch remaining in the digestive tract of rodents. Acta theriol., 34, 24: 339—346 [With 2 Tables & 2 Figs].

In the linear method of evaluation of rodent population size it is important to know how long oat starch remains in the digestive tract in order to determine the spatial activity of these animals. For this purpose, during 48 hours the rodents *Clethrionomys glareolus* (Schreber, 1780), *Apodemus flavicollis* (Melchior, 1834) and *Apodemus agrarius* (Pallas, 1771) received green fodder and water as food. After that time period they fasted for one hour, and then each animal was given 5 g of oat grains. Then at 2-hour intervals for 50 hours 1—2 animals of each species were killed. The presence of oat starch was determined in the stomach, small intestine and caecum. The reduction of the percent of oats in the stomach with time showed a linear correlation to the time after oats consumption. The maximal time of oats remaining in the stomach of these rodents was similar in all three species, up to 40 hours. In the small intestine oats were found for the longest — up to 48 hours — in field mice, and in the caecum, oats were present in all species throughout the whole experiment, that is 50 hours.

[Warsaw Agricultural University, Faculty of Forestry, Department of Game Management, Rakowiecka 26/30. 02-528 Warsaw, Poland].

1. INTRODUCTION

Recently, studies have been published using a linear evaluation of the size of rodent populations (Andrzejewski & Babińska-Werka, 1986, and unpubl., Liro & Szacki, 1987). This method was used earlier by Soviet authors (Kučeruk, 1963; Nikitina, 1961), but in the Polish studies there was also a simultaneous feeding of rodents with oat grains or cake with coloured woolen yarn in several places along the line of animal catching. Andrzejewski and Babińska-Werka (1986, and unpubl.), conducting studies along catching lines 1200 and 4000 m long, demonstrated that in a radius of 300 m from the feeding site, oats were found in the stomach of *Clethrionomys glareolus* (Schreber, 1780). In the case of the forest mouse *Apodemus flavicollis* (Melchior, 1834) oat starch was found in the stomach of animals caught 400—450 m from the source of oats (Andrzejewski &

Babińska-Werka, unpubl.). Liro and Szacki (1987) caught many field mice, *Apademus agrarius* (Pallas, 1771) 700 to more than 1000 m from the site of the coloured bait.

Andrzejewski and Babińska-Werka (1986) accepted the simplest hypothesis that thee animal having oat starch in the stomach had visited the source of oats. Determining on this basis the areas occupied by *Clethrionomys glareolus* they suggested that these areas were several times larger than those accepted in the literature (Aristova, 1970; Mazurkiewicz, 1981, 1983). This fact aroused criticism (Bujalska, 1988; Grüm, 1988). Grüm proposed a computer model of area utilization by *Clethrionomys glareolus* assuming that the time of oats remaining in the stomach of rodents was from 2,5 to 3 hours. On the basis of this model Grüm found that in such a short time the animal could not wander 300 m.

In the accepted method of linear estimation of rodent population size it is importaant to know how long starch remains in the stomach in order to determine the range of spatial activity of rodents. The data on this subject vary, ranging from 8 hours (Pravdina, 1958) to 48 hours (Kostelecka-Myrcha & Myrcha, 1964) and even to 8 days (Ryszkowski, 1968). In the digestive tract of *Clethrionomys glareolus* the latter author found oat starch coloured with basic fuchsin in trace amounts in the stomach and in larger amounts in the caecum.

The purpose of the present study was to determine how long oat starch remained in the digestive tract of rodents.

2. METHODS AND MATERIAL

The study was carried out on three rodent species caught in the area under study. The material comprised 66 bank voles, *Clethrionomys glareolus*, 41 field mice, *Apodemus agrarius*, and 39 forest mice, *Apodemus flavicollis* (Table 1). The rodents were brought to the laboratory and placed in wire cages. For at least 48 hours they received exclusively green fodder and water *ad libitum*. Then, for 1 hour the animals were given no food, and after that time each animal was given 5 g of oats. Oats were available to the rodents for 2 hours, and after that time the rodents were transferred again into cages with green fodder and water. During the following 50 hours 1—2 animals of each species were killed at 2-hour intervals. After death the animals were weighed, and their sex and reproductive condition were determined. The stomach was removed and its oat content determined up to a 10% accuracy. The presence of oat starch grains was determined by staining the gastric contents with Lugol solution and with microscopic examination of starch grains. Lugol solution was used also for determination of oat starch in the entire small intestine and caecum. For conformation of the presence of oat starch in these parts of the digestive tract micro-

Table 1
Characteristics of the studied rodents.

Species	Number		Per cent of animals sexually		Mean body weight (g)
	Females	Males	inactive	active	
Clethrionomys glareolus	31	35	84.9	15.1	15.71±0.42
Apodemus flavicollis	21	18	77.0	23 0	14.79±0.62
Apodemus agrarius	22	19	85.3	14.7	16.02±0.62

scopic analysis was done. No quantitative analysis of oat grains in these parts was done. When oats were absent or present in only negligible amounts in the stomach the number of animals killed was increased (up to 6) in order to more accurately estimate the maximum time during which the grains remained in this part of the digestive tract.

3. RESULTS

3.1. The Time of Oats Remaining in the Rodent Stomach

In the experiment similar number of males and females were used. Most of the rodents caught were sexually inactive, since they were caught in September and had been born that same year.

The per cent changes of oats in the gastric contents of the animals were analysed as a function of the time ofter oat consumption by the rodents. In all species a linear correlation was found which was statistically significant ($p<0.05$) and negative (Fig. 1). This means that the amount of oat starch in the stomach of these animals decreased propor-

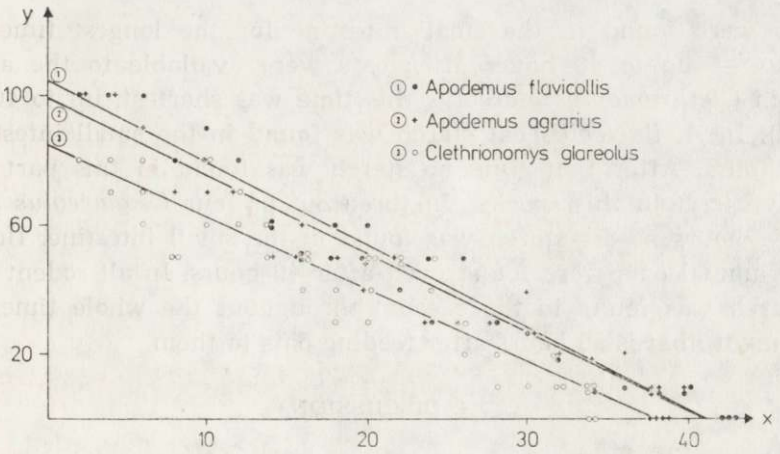

Fig. 1. Relationship between the per cent proportion of oats present in rodent stomach (y) and the time in hours (x) after oats presentation to the animals.

Table 2

Changes of oats content in rodent stomach depending on the time after consumption.

Species	N animals	Regression equation	Correlation coefficient	Max time of oats staying in stomach (hours)
C. glareolus	41	$y=-2.24\ x+\ 84.76\pm6.48$	−0.924	38.84±2.89
A. flavicollis	29	$y=-2.53\ x+103.73\pm6.60$	−0.968	41.00±2.61
A. agrarius	29	$y=-2.44\ x+100.12\pm6.82$	−0.970	41.03±2.80

tionally to the time of consumption. Using simple regression equations the maximal time of oats remaining in the stomach (x) was calculated, assuming that the content (y) of oats in the stomach equalled 0. This time was from 38 hours for *Clethrionomys glareolus* to 41 hours for both mice species (Table 2). The difference was not statistically significant.

The aim of further analysis was to determine whether the time of oats remaining in the stomach was different for males and females and for animals differing in body weight which ranged from 9 to 25 g. In each species the animals were divided into two groups, with body weight above or below the mean. The mean body weight of *C. glareolus* and *A. flavicollis* was 15 g, and that of *A. agrarius* was 16 g. No statistically significant differences were found in the shape of regression lines illustrating oat loss from the stomach, and in the maximal time of oats in the stomach in the analysed rodent groups.

3.2. Oats Presence in the Small Intestine and Caecum

Oats were found in the small intestine for the longest time in *A. agrarius* — up to 48 hours after oats were available to the animals, while in *Clethrionomys glareolus* this time was shortest, up to 40 hours (Fig. 2). In *A. flavicollis* oat starch was found in the small intestine up to 42 hours. After that time no starch was found in this part of the digestive tract in this species. In three out of four *C. glareolus* already after 34 hours no oat starch was found in the small intestine. However, in one animal oats were found even after 40 hours. In all rodent species oat starch was found in the caecum throughout the whole time of the experiment, that is 50 hours after feeding oats to them.

4. DISCUSSION

Only a few publications were found on the time of seeds remaining in the digestive tract of rodents. According to Voroncov (1961) and Myrcha

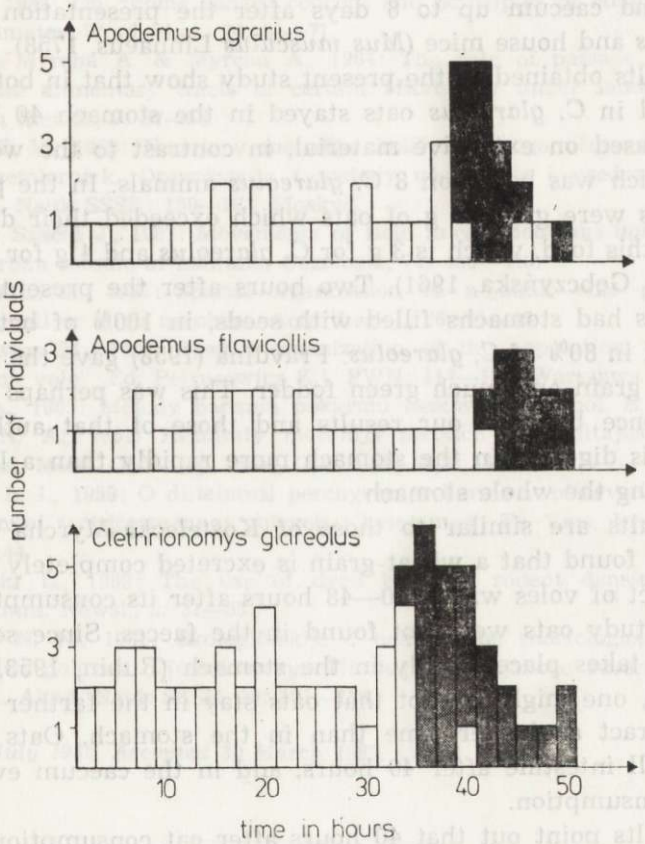

Fig. 2. Oats in small intestine of rodents. Clear areas — oats, dark areas — no oats.

(1965), the stomach, besides its digestive function, serves also as a transient storage space where food remains the longest. In the glandular part of the stomach the seeds undergo the main process of breakdown in rodents (Rubin, 1953, after Pravdina, 1958). Because of that, in the determination of how long seeds remain in the digestive tract, most attention is paid to the stomach in rodents. The content of seeds in the remaining parts of the digestive tract provides only peripheral information (Voroncov, 1961).

The data on the duration of seeds staying in the rodent stomach differ widely. According to Pravdina (1958) in the *Microtus* genus seeds may be found in the stomach for up to 6.5 hours after their consumption, and in *Apodemus* mice up to 8 hours. On the other hand, Adamczyk and Ryszkowski (1968) and Ryszkowski (1968) found traces of oats in the

stomach and caecum up to 8 days after the presentation of seeds in *C. glareolus* and house mice (*Mus musculus* Linnaeus, 1758).

The results obtained in the present study show that in both *Apodemus* species and in *C. glareolus* oats stayed in the stomach 40 hours. These data are based on extensive material, in contrast to the work of Ryszkowski which was based on 8 *C. glareolus* animals. In the present work the rodents were given 5 g of oats which exceeded their daily requirements for this food, which is 3 g for *C. glareolus* and 4 g for *A. flavicollis* (Górecki & Gębczyńska, 1961). Two hours after the presentation of oats the animals had stomachs filled with seeds, in 100% of both *Apodemus* species and in 80% of *C. glareolus*. Pravdina (1958) gave the animals only one wheat grain and much green fodder. This was perhaps the cause of the difference between our results and those of that author. Perhaps one grain is digested in the stomach more rapidly than a large amount of oats filling the whole stomach.

Our results are similar to those of Kostelecka-Myrcha and Myrcha (1964) who found that a wheat grain is excreted completely from the digestive tract of voles within 40—48 hours after its consumption.

In this study oats were not found in the faeces. Since seed digestion in rodents takes place mainly in the stomach (Rubin, 1953, after Pravdina, 1958), one might except that oats stay in the farther parts of the digestive tract a shorter time than in the stomach. Oats were found in the small intestine after 40 hours, and in the caecum even 50 hours after its consumption.

The results point out that 40 hours after oat consumption by rodents starch from oats may be found in the stomach of the animals. This is the time in which a specific food may be used for labelling of rodents.

Acknowledgements: The study was carried out as part of the programme C.P.B.P. 04.10 coordinated by the Warsaw Agricultural University.

REFERENCES

1. Adamczyk K. & Ryszkowski L., 1968: Estimation of the density of a rodent population using stained bait. Acta theriol., *13:* 295—311.
2. Andrzejewski R. & Babińska-Werka J., 1986: Bank vole population: are their densities really high and individual home range small? Acta theriol., *31:* 409—422.
3. Aristova V. A., 1970: Osobennosti ispolovanija teritorii krasnoj polevki w lesach južnoj časti Kirovskoj oblasti. Fauna Ekologija Gryzunov, *9:* 151—159.
4. Bujalska G., 1988: Populacje nornicy rudej: Czy rzeczywiście ich zagęszczenie jest małe a areały osobnicze duże? Wiad. ekol., *34:* 73—78.
5. Górecki A. & Gębczyńska Z., 1962: Food conditions for small rodents in a deciduous forest. Acta theriol., *6:* 275—295.

6. Grüm L., 1988: On "home range" concept and principles of compability of its aspect estimates. Wiad. ekol., *34:* 61—71.
7. Kostelecka-Myrcha A. & Myrcha A., 1964: The rate of passage of foodstuffs through the alimentary tracts of certain *Microtidae* under laboratory conditions. Acta theriol., *9:* 37—53.
8. Kučerek V. V., 1963: Navoje v metodike količestvennogo učeta vrednych gryzunov i zemlerojek. Organizacija i metody učeta ptic i vrednych gryzunov. Izd. Akad. Nauk SSSR: 159—183. Moskva.
9. Liro A. & Szacki J., 1987: Movements of field mice *Apodemus agrarius* (Pallas) in a suburban mosaic of habitats. Oecologia, *74:* 438—440.
10. Mazurkiewicz M., 1981: Spatial organization of a bank vole population in years of small or large numbers. Acta theriol., *26:* 31—45.
11. Mazurkiewicz M., 1983: Spatial organization of the population. [In: "Ecology of the bank vole", Ed. Petrusewicz K.]. PWN: 117—128. Warszawa.
12. Myrcha A., 1965: Metody badania pokarmu ssaków. Ekol. pol. B, *11:* 243—253.
13. Nikitina N. A., 1961: Rezultaty mečenija melkich mlekopitajuščich v Komi ASSR. Bjul. Mosk. Obšč. Isp. Prir., Otd. biol., *66,2:* 15—25.
14. Pravdina L. I., 1958: O dlitelnosti perebyvanija korma v piščevaritelnom trakte obyknovennoj i obščestvennoj polevok i beloj myši. Tr. Vses. Inst. Zašč. Rast., *12:* 138—144.
15. Ryszkowski L., 1968: The use of dyed bait for rodent density estimation. Small Mamm. Newsl., *2:* 31—35.
16. Voroncov N. N., 1961: Ekologičeskije i nekotoryjne morfologiceskije osobennosti ryžich polevok (*Clethrionomys Tilesius*) evropejskogo severo-vostoka. Tr. Zool. Inst. Akad. Nauk SSSR, *29:* 101—136.

Received 10 July 1988, Accepted 30 March 1989.

Joanna BABIŃSKA-WERKA i Dariusz MATYJA

CZAS PRZEBYWANIA SKROBI OWSA W PRZEWODZIE POKARMOWYM GRYZONI

Streszczenie

W liniowej metodzie oceny liczebności gryzoni informacje o czasie przebywania skrobi owsa w przewodzie pokarmowym ma istotne znaczenie dla określenia zakresu aktywności przestrzennej tych zwierząt. W tym celu u trzech gatunków gryzoni: *Clethrionomys glareolus* (Schreber, 1780), *Apdemus flavicollis* (Melchior, 1834) i *Apodemus agrarius* (Pallas, 1771) zbadano czas przebywania owsa w przewodzie pokarmowym. Przez 48 godzin gryzonie karmiono indywidualnie pokarmem zielonym i wodą. Po tym czasie głodzono je przez 1 godzinę, a następnie podano po 5 g ziarna owsa, po czym przez 50 godzin w odstępach co 2 godziny zabijano 1—2 osobniki każdego gatunku. Sprawdzano obecność skrobi owsa w żołądku, jelicie cienkim i ślepym. Ilość owsa w żołądku określano z dokładnością do 10%. Procentowy spadek zawartości owsa w żołądkach w miarę upływu czasu od

pobrania go przez zwierzęta wykazywał zależność prostoliniową (Tabela 2, Ryc. 1). Maksymalny czas przebywania owsa w żołądkch gryzoni był podobny u wszystkich gryzoni i wynosił 40 godzin (Tabela 2). U badanych gatunków nie stwierdzono różnic statystycznie istotnych w przebiegu prostych regresji ubywania owsa z żołądków i w maksymalnym czasie przebywania skrobi w żołądkach u samic i samców oraz u osobników o ciężarze do 15 g i powyżej 15 g. W jelicie cienkim najdłużej wykrywano owies u myszy polnej — do 48 godzin, a w jelicie ślepym u wszystkich gatunków gryzoni przez 50 godzin po podaniu nasion (Ryc. 2).