Paper

Effects of bedding material and running wheel surface on paw wounds in male and female Syrian hamsters

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Abstract

The present study investigated the effects of bedding material (pine shavings versus beta chip) and running wheel surfaces (standard metal bars versus metal bars covered with a plastic mesh) on the occurrence of wounds on the paws of male and female Syrian (golden) hamsters, *Mesocricetus auratus*. Four groups of 10 males and 10 females were each assigned to one of the following treatments: pine/no mesh, pine/mesh, chips/no mesh and chips/mesh. Each hamster paw was observed at 1–3-day intervals for 60 days. A total of 1–3 wounds, separate in time, developed on the paws (mostly the hind ones) of almost all animals. Wounds appeared as small pinpricks, cuts or scabs, mostly on the palms. Females ran 15% less than males, yet their front paws were more commonly affected and their wounds tended to last longer. Hamsters with plastic mesh inside their wheels took longer to develop wounds but once they appeared, the wounds were larger and lasted longer. Hamsters on pine shavings developed fewer wounds and had more wound-free days. Hamsters kept running at high levels and many wounds did not heal during the study, suggesting a need for veterinary intervention.

Keywords: Syrian hamster, golden hamster, running wheel, bedding material, paw condition, animal welfare

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Relatively few animal welfare studies have been conducted on hamsters, despite the fact that considerable use is made of these animals in biochemical and behavioural – mostly chronobiological – research. According to the Canadian Council on Animal Care,[1] a total of 6204 hamsters were used for research purposes in 2005 in Canada, making them the fourth most popular laboratory rodent after mice, rats and guineapigs. Among the aspects of hamster welfare that have been studied so far are social housing,[2] nest boxes,[3] cage floor preference,[4,5] cage dimension,[6,7] environmental enrichment,[8] running wheels,[9–11] and bedding material.[12,13] Kuhnen[14] and Sørensen *et al.*[15] provide reviews of housing requirements for hamsters, and Gattermann *et al.*[16] gives information on the poorly known ecology of this species in the wild.

Exercise wheels are usually provided in hamster cages as environmental enrichment and, in the case of chronobiological research, as a means to measure activity phase. Syrian (golden) hamsters, *Mesocricetus auratus*, placed in the presence of a running wheel for the first time can easily and spontaneously run up to 9 km per night.[7,9,17,18] Such high levels of running are also observed in our laboratory.[8,11] We also noticed that, possibly as a result of such running, cuts and wounds often appear on the paws of our Syrian hamsters.[11,13] These wounds scab over, eventually heal, and do not seem to unduly bother the animals, as these continue to run extensively. Nevertheless, we wanted to determine whether some parameters could be identified that promoted the appearance – or, conversely, accelerated the healing – of these wounds. A second objective was to quantitatively describe the occurrence of the wounds.

If paw wounds are related to running, then the sex of the animals and the nature of the running surface are two parameters amenable to study. In our laboratory, males tend to run more than females[11] and therefore males might be more prone to paw injuries. Again in our laboratory, wheel-running surface may consist either of metal bars 2 mm thick separated by 7 mm of open space, or of a plastic mesh (Vexar®, Masternet Inc, Mississauga, Canada) with ribs 1.2 mm thick forming openings of 4×4 mm laid over the metal bars. A previous study[11] found that hamsters expressed no preference for either of these two surfaces, but the effect of the running surface on paw condition was not systematically investigated.

Yet another parameter is the type of bedding material present in the cages. Lanteigne and Reebs[13] hypothesized that pine shavings might get wedged between the bars of the running wheels and cut the paws, or that various compounds in pine wood could soften the paws and make them more prone to cuts and abrasions.[19–21] However, Lanteigne and Reebs[13] noted no significant difference between pine shavings, aspen shavings and corn cob in their effect on wound number and severity (in fact, pine shavings tended to lead to better paw condition, but not significantly so). Here, we decided to compare pine shavings with another type of bedding, small heat-treated hardwood chips, using more varied measures of paw condition.

Materials and methods

This experiment was conducted under approval by the Université de Moncton's Animal Care Committee (protocol #05-03).

A total of 80 Syrian hamsters (40 males and 40 females) were used. The strain was Crl:LVG (SYR) obtained from Charles River Canada in four separate batches (two batches of 20 males and two of 20 females) aged about 60 days. Upon arrival in the laboratory, each of the 20 hamsters was placed in its own cage so that five hamsters were randomly assigned to each of four treatments: pine/mesh, pine/no mesh, chips/mesh and chips/no mesh. Each polypropylene cage (translucent white, $47 \times 26 \times 20$ cm, 'F-size' for rats, Nalgene) contained 1 L of bedding material spread on the floor. In the case of the pine treatment, the bedding consisted of pine shavings (Pet Pal Corp, Carlsbad, CA, USA) that had an approximate size of $10\,\text{mm} \times 4\,\text{mm}$. In the case of chips treatment, the bedding consisted of heat-treated hardwood flakes (Beta Chip®, Northeastern Products Corp, Warrensburg, NY, USA) that were about $2\,\text{mm} \times 4\,\text{mm}$. Each cage was equipped with a running wheel (35 cm diameter, 'F-size' for rats, Nalgene) with metal rods 9.5 cm long and 2 mm thick, spaced 9 mm apart (actual open space between rods: 7 mm). In the case of no mesh, the rods were bare, whereas in the case of mesh, a strip of plastic mesh (see Introduction) was pushed against the metal wheel from the inside and secured in place by small-gauge electronic wire ties. Except for the first batch of 20 males, each wheel was connected to a micro-switch that tallied the number of nightly wheel revolutions (no data on wheel revolutions are available for the first batch of 20 males). Nightly wheel revolutions were noted once or twice a week. Water and food (pellets for rodents, Living World®, Rolf C Hagen Group, Montreal, Canada) were available *ad libitum* and replaced as needed.

The 20 cages were kept side by side on tables in a single room kept at $21 \pm 1^\circ$C, under a 14:10 h light:dark cycle. Light was provided by incandescent lights, resulting in a mean intensity of 81 lux (Lunasix 3, Gossen) within each cage. Litter was changed at 10-day intervals, at which time each hamster was weighed.

Every 1–3 days for 60 days, each hamster was taken out of its cages and restrained inside a rectangular transparent plastic container ($14.5 \times 8.5 \times 6$ cm). The colour, general appearance and position (palm or toes) of each paw wound were noted. The length (± 0.5 mm) of the long and short axes of each wound was measured with a ruler.

The following variables relating to paw condition were calculated for each hamster: (1) latency to first wound = the number of days until the first wound appeared; (2) number of wounds = the total number of separate wounds, both spatially and temporally; (3) number of legs = the total number of legs on which at least one paw wound appeared; (4) wound-free days = the total number of days, out of 60, when no wound was present; (5) wound-days = the number of days that a wound was present, totalled for all wounds; (6) wound-day-size = same as wound-day, but multiplied by the size (short axis $\times$ long axis) of the wound each day; and (7) largest wound size = largest size (short axis $\times$ long axis) of any wound observed on that animal. Non-observation days at the beginning or end of a wound presence were counted as half-days in the calculation of any variable involving days. Wound duration was calculated and some values were reported, but this variable was not included in the main analysis because many wounds had not disappeared by the end of the experiment and thus their true duration could not be established.

Two other variables calculated for each hamster were weight gain, taken as the difference between the weight at the beginning and end of the 60-day experiment, and average nightly wheel revolutions, taken as the mean of eight single night measurements, one for each of the first eight weeks of the experiment.

Variables were analysed with three-way ANOVAs (SPSS for Windows v.12, Chicago, IL, USA), with sex (male or female), mesh (present or absent) and litter (pine or chips) as fixed treatments. *t*-tests, χ^2-tests and Pearson's correlation tests were also used (SPSS for Windows v.12). Significance level was set at $P = 0.05$, and P values between 0.05 and 0.10 were noted as tendencies or nearly significant results. Though means on the figures are accompanied by standard errors, in the text and tables, they are accompanied by standard deviations.

Results

Quantitative description

Only two of the 80 hamsters (one male and one female) did not exhibit any paw wound during the 60 days of the study (Table 1). Conversely, only six females and no males developed wounds on all four paws. The most common condition, especially in males, was to have both hind paws and none of the front paws affected (Table 1). Only five of the 40 males ever showed wounds on a front paw (intriguingly, always the right one), whereas 19 of the 40 females had one or both front paws involved (fairly evenly divided between the right and left ones, Table 1). This difference in the proportion of males and females affected on the front paws is significant ($\chi^2 = 11.66$, $P < 0.001$).

The maximum number of wounds per paw never exceeded three, and multiple wounds per paw were almost always separate in time. The average number of wounds per paw (including cases when no wounds were present) was 1.40 ± 0.63, 1.30 ± 0.85, 0.48 ± 0.83, and 0.38 ± 0.59 for the rear right, rear left, front right and front left paws, respectively ($n = 80$).

Table 1 Mean ($\pm$SD) number of wounds observed on each paw of female and male hamsters during the 60-day experiment

	n	Rear right	Rear left	Front right	Front left
Females	1	×	×	×	×
	3	1.67 ± 0.58	×	×	×
	17	1.35 ± 0.49	1.65 ± 0.61	×	×
	3	1.66 ± 0.58	1.33 ± 0.58	1.66 ± 0.58	×
	6	1.33 ± 0.82	1.17 ± 0.41	1.33 ± 0.52	1.00 ± 0.00
	7	1.57 ± 0.79	1.86 ± 0.90	×	1.29 ± 0.49
	3	1.33 ± 0.58	×	2.00 ± 1.00	×
Males	1	×	×	×	×
	3	1.00 ± 0.00	×	×	×
	30	1.70 ± 0.79	2.03 ± 1.27	×	×
	5	1.40 ± 0.55	2.00 ± 1.22	1.20 ± 0.45	×
	1	×	1.00 ± 0.00	×	×

The rows are broken down according to the combination of legs affected on the animals

The wounds were usually located on the palm (81.1%), with the base of a toe (17.1%) or a toe (1.8%) being the other positions. The nature of the wound could be a small dot, a cut 1–3 mm long or a scab of various sizes (Figure 1). The colour was usually dark red, but it could also be black, light or dark brown, or light or dark yellow. Shape, size and colour changed throughout the lifetime of a wound. Of those wounds that healed during the study, mean duration was 10.97 ± 9.76 and 13.97 ± 12.83 days for males and females, respectively (the difference is nearly significant: $t = 1.757$, $P = 0.081$, $n = 103$ and 105). Of the wounds that did not heal completely and that were still present at the end of the study, mean duration was 39.4 ± 13.22 and 41.5 ± 16.42 days for males and females, respectively ($t = 0.566$, $P = 0.573$, $n = 29$ and 38).

Effect of sex

Females had slightly but significantly larger weights than males at the start of the experiments (115 ± 4.3 g versus 112 ± 3.6 g; $t = 3.670$, $P < 0.001$, $n = 40$ and 40). By the end of the experiments, females had also gained significantly more weight than males (females: 46 ± 13 g, males: 19 ± 10 g). Females ran in their wheels significantly less than males (by 15% on average; Figure 2A, Table 1) but running the ANOVA with wheel revolutions as a covariate still yielded a significant difference between male and female weight gains ($F = 59.58$, $P < 0.001$).

There was a significant sex effect for five of the seven paw wound variables, females consistently showing worse paw conditions (Figures 2D–H, Table 2). This is in spite of the fact that females ran significantly less. Although the total number of wounds did not differ between the two sexes, wounds tended to be larger and to last longer in females, leading to higher values of wound-days, wound-day-size and largest wound size, and to lower values of wound-free days. Females also had more legs affected than males, consistent with the observation that front legs were affected mostly in females.

There was no significant correlation between any of the seven wound variables and either the individual weight gain or the final body weight, be it within all males pooled together or within all females pooled together or within each group of 10 males or 10 females, with the following exception: among the 10 females that were assigned to the chips/no mesh treatment, higher weight gain and higher final body weight were correlated with longer latency to first wound ($P < 0.008$), fewer wounds ($P < 0.042$) and fewer legs affected ($P < 0.036$).

Effect of running surface

First wounds appeared significantly more slowly in animals provided with mesh inside their running wheel (Figure 2B, Table 2). However, values for wound-day-size and for largest wound size were significantly greater in the mesh groups, and there was also a tendency ($P = 0.09$) for wound-days to be higher (Figures 2F–H, Table 2). These worse indices (latency to first wound notwithstanding) cannot be attributed to more running activity because the mesh groups in fact ran significantly less (by 24% on average; Figure 2A, Table 2).

Effect of bedding material

Paw condition was better in the pine shavings groups. There was no difference with the beta chip groups for latency to first wound, but number of wounds, wound-days and Wound-day-size were all significantly lower for pine shavings; number of legs affected was almost significantly lower ($P = 0.093$) and number of wound-free days was significantly higher (Figure 2, Table 2). There was a tendency ($P = 0.062$, Table 2) for the pine shavings animals, especially the males, to run less (Figure 2A) which might explain their better paw condition, but the significant ANOVA results are maintained, or very nearly

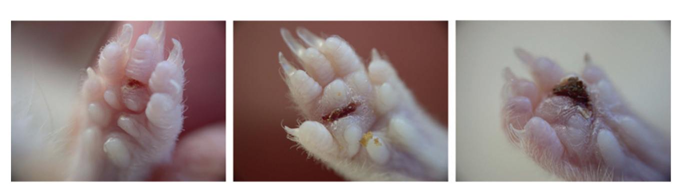

Figure 1 Examples of wounds on hamster paws, including a front leg (leftmost image)

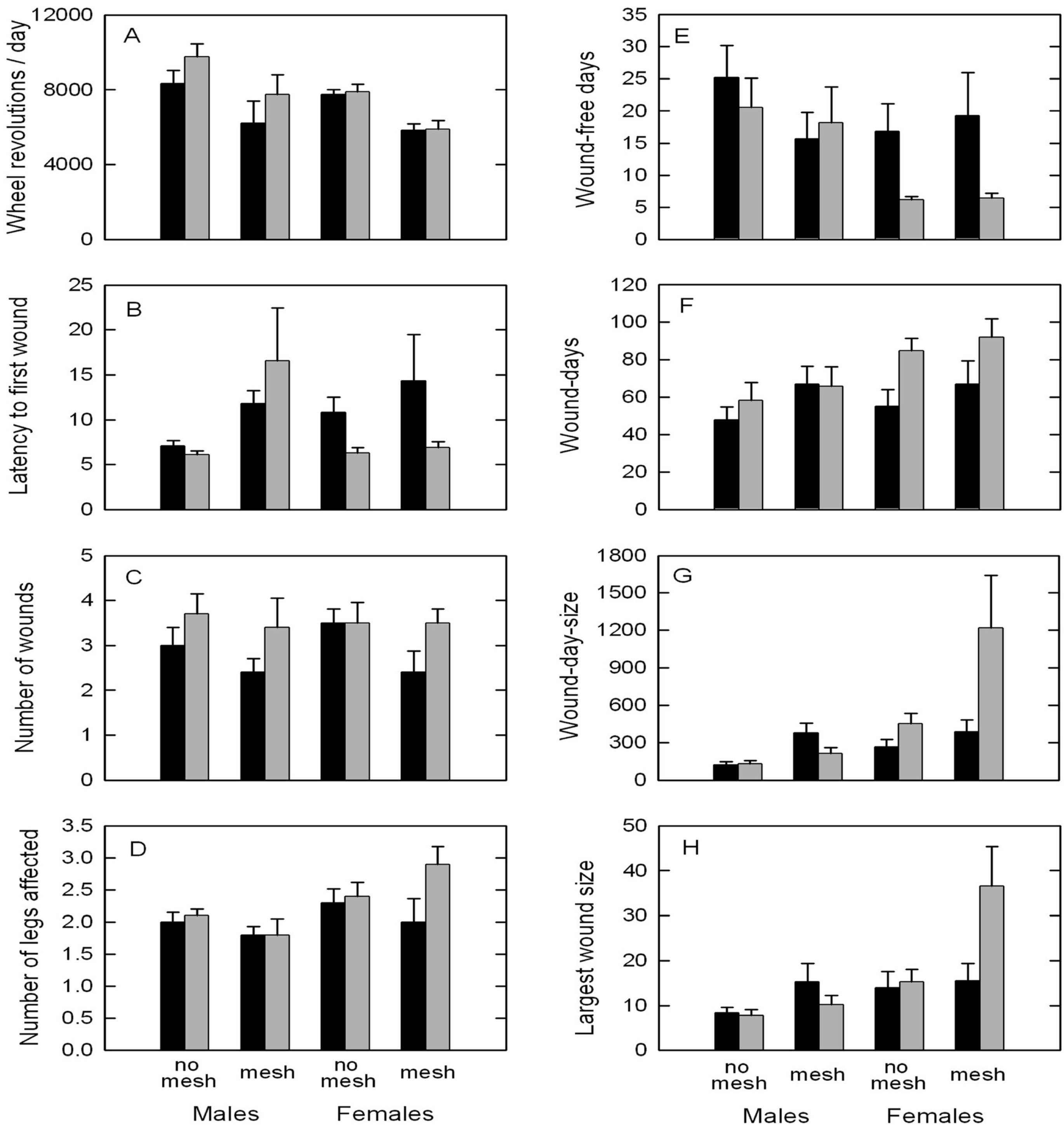

Figure 2 Mean (±SE) number of nightly wheel revolutions (A) and paw condition (B–H) in male and female hamsters with pine shavings (black bars) and hardwood chips (grey bars) as bedding material, and with or without a plastic mesh over the metal bars of their running wheel. $n = 10$ except for males' wheel revolutions where $n = 5$

so, when the variable wheel revolutions are included as a covariate (number of wounds: $F = 3.680$, $P = 0.061$; wound-free days: $F = 7.375$, $P = 0.009$; Wound-days: $F = 6.553$, $P = 0.013$; Wound-day-size: $F = 3.545$, $P = 0.065$ and latency to first wound becomes significant: $F = 4.972$; $P = 0.030$).

Discussion

Effect of sex

Our result that males ran more than females replicates the observations of Reebs and St-Onge.[11] However, the prediction that such high running would lead to more paw

Table 2 *P* values from three-way ANOVAs conducted on weight gain and the data shown in Figure 2

	Sex	Mesh	Litter	SxM	SxL	MxL	SxMxL
Weight gain	**<0.001**	0.412	0.546	0.085	0.122	0.465	0.624
Wheel revolutions	**0.007**	**<0.001**	0.062	0.877	0.105	0.999	0.900
Latency to first wound	0.689	**0.021**	0.327	0.181	0.060	0.725	0.293
Number of wounds	0.745	0.107	**0.025**	0.871	0.625	0.256	0.515
Number of legs	**0.004**	0.644	0.093	0.282	0.168	0.294	0.186
Wound-free days	**0.017**	0.473	**0.045**	0.248	0.093	0.687	0.454
Wound-days	**0.029**	0.091	**0.020**	0.783	0.094	0.542	0.800
Wound-day-size	**0.002**	**0.009**	0.063	0.222	**0.011**	0.301	0.076
Largest wound size	**0.005**	**0.008**	0.155	0.255	**0.020**	0.201	**0.043**

Significant values ($P < 0.05$) are in bold

wounds was not upheld. On the contrary, in many respects, males had better paw condition than females. Perhaps, this indicates a reversed cause-and-effect relationship, with females running slightly less (by 15% on average) as a consequence of their larger or longer lasting wounds. Or perhaps, males can heal their wounds faster, as suggested by the nearly significant difference between the sexes in the duration of those wounds that healed during the study. None of these potential explanations, however, addresses the finding that females developed wounds on their front paws much more often than males.

Females gained more weight than males. Females have an intrinsic tendency to grow more than males, and it is known that they are usually larger than males.[14] Borer[22] reported that exercised hamsters gained more weight than sedentary ones, but this cannot be used to explain the superior growth we observed in females because our females actually ran less than males on average (and at any rate, the higher weight gain by females remained significant after wheel running was taken into account as a covariate).

Effect of running surface

The mesh groups ran about 24% less in their wheels, which may explain their higher latency to first wound, but not their higher wound-day, wound-day-size and largest wound size values. As compared with bare metal rods, a plastic mesh surface is not as hard but presents a larger surface of contact for the paws. Metal bars can be grabbed with the toes only; whereas, a good part of the palm comes in contact with the mesh on each step. The hard metal may induce wound formation more quickly,[23] but once a wound is present, it may take longer to heal in the case of a mesh surface because of the increased friction on a larger part of the palm.

Effect of bedding material

Pine shavings led to better paw condition than beta chip. This result is in line with that of Lanteigne and Reebs[13] who observed slightly (though not significantly) fewer paw wounds and a lower overall scab severity in hamsters housed on pine shavings as compared with aspen shavings or corn cob. The mechanism by which pine shavings decrease wound occurrence is unclear.

One must bear in mind that several factors come into play when choosing a bedding material for hamsters.[24] Bedding material must be clean, dry, not toxic,[25] free of carbohydrates which increase the activity of the hepatic enzymes[19,26] and of aromatic components that can be carcinogenic.[20] The capacity of bedding material to double up as nesting material can also be taken into consideration[13] and now we must add, and continue investigating, its effect on paw condition in hard-running hamsters.

Severity of the wounds

All hamsters kept running at relatively high levels despite the occurrence of wounds on their paws. It remains possible, however, that the most severe wounds hindered wheel running to a certain extent, something that our once-a-week wheel measurements do not allow us to investigate. Daily measurements will be necessary in the future to correlate the appearance of a wound, or its development beyond a certain size, with any sudden decrease in wheel-running activity.

Irrespective of the degree of its impact on a hamster's ability to use its running wheel, in animal welfare terms, the appearance of wounds on the paws is a problem. The present study provides a first description of this wound problem, and identifies at least one easy choice that can be made in the lab to minimize it: the use of pine shavings as bedding. However, the cause of the problem remains unknown. Wear and tear due to excessive running is a possibility that can be investigated in the future by limiting to various extents the access to a running wheel. The possibility of cuts caused by bedding material (especially while the animal is running) could be studied through the removal of bedding. Finding the source of the wound problem will undoubtedly point to more solutions for minimizing it. In the meantime, palliative veterinary care may be indicated, especially given the number of wounds/scabs that lasted for 40 days or more in this study.

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