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On the Risk of Stepping into a Cowpat when Crossing a Pasture

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Abstract. Stepping into a cowpat is a common nuisance for millions of farmers around the globe. Due to a rising demand for meat as a consequence of population growth and the desire for species-appropriate husbandry, huge amounts of cow pastures are accessed to meet these requirements. As a result, the frequency of unwelcomed missteps increases. To investigate the risk of an unpleasant encounter with a cow's legacy, a simulation study has been conducted on the basis of two-dimensional random walks, incorporating various scenarios of different shoe sizes, step lengths, number of steps and number of cowpats. The length of a random walk did not affect the mean number of steps into a cowpat (p=0.964). On average, people with smallest investigated shoe size had 8.9 (SD 5.8) missteps less than those with largest shoe size. The number of missteps decreases if the length of a crossing walk increases, moreover misstep frequency shows some kind of an asymptotic behaviour. Crossing cow pastures without explicitly watching each step does not require to keep the walk preferably short in order to minimize the risk of stepping into a cowpat. The more cowpats on a pasture are, the more beneficial is it to have small feet.

Key Words: Random walk; farming; hiking; messy shoes.

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Introduction

Farmers and hikers around the world spend countless hours on pastures every day. Although the motivation for both groups fundamentally differs, they share the nuisance of messy shoes due to unwelcomed steps into cowpats. Admittedly, it has been shown that availability of cowpats is important for invertebrate diversity in farmland landscapes [1], but on the other hand resulting missteps of pasturage-crossing people are problematic for many reasons. Hence, it is a matter which requires further consideration. First of all, increased incidence rates have to be assumed due to constant population growth and an associated rising demand for beef and pastures, respectively, so it will remain a relevant issue in the future. Furthermore, missteps into cowpats are a significant problem from a medical as well as an ecological perspective. Undergoing such an event repeatedly may have adverse effects on somebody's mood, resulting in mental stress and a concomitant increased risk for depression, hypertension and stroke [2,3,4]. A major ecological consequence of messy shoes is an increase in water consumption due to attempts to get them clean again. Assuming 50,000 unwelcomed events per day worldwide (event rate of 0.0007%) and an average amount of water of 2 litres per event to clean up, a total amount of 36,500 m^3 of water would be necessary per year. This is equivalent to the average one-year per head consumption of more than 1,000 people in the industrial countries and almost 2,000 people in African arid areas.

To investigate which determining factors affect the risk of stepping into a cowpat, a simulation study has been conducted considering the most basic parameters which are related to an a priori unspecific walk across a pasture. Specifically, the effects of shoe size, length of a walk and length of each step were analysed. Primary hypothesis was that the number of missteps increases with the length of a crossing walk.

Material and Methods

Random walk model

To simulate a person's reckless walk across a patch of land where previously a herd of cows enjoyed a sunny afternoon, a random walk process in two dimensions was considered. Let X_i and Y_i ($i=1,\ldots,n$) be two sequences of real-valued and equally distributed random variables which form $Z_i=(X_i,Y_i)$, then the stochastic process

$$R_n = R_0 + \sum_{i=1}^{n} Z_i$$

is called a two-dimensional random walk [5]. Without loss of generality, R_0 can be assumed to be (0,0). For the conducted simulations, all X_i and Y_i were defined to be uniformly distributed on the interval 0 to 3, leading either to a forward step direction if $0 \leq X_i, Y_i \leq 1$, to a backward step direction if $2 < X_i, Y_i \leq 3$, or to no change in the respective direction otherwise.

Simulation scenarios

Different simulation scenarios were created by varying the four determining factors number of steps, number of cowpats, step length and shoe size. The default number of steps was set to 800 (defines an average walk) with alternatives of 400 (fast crossing of restless hikers) and 1200 steps (faithful farmers inspecting their piece of land). An initial number of uniformly distributed cowpats was set to 40 with an average diameter of 0.3 meters. To describe situations of constipated and scours-affected animals, additional quantities of 20 and 100 cowpats were assumed, respectively. The step length was either defined fixed with 0.5 meters or assumed to be normally distributed with $N(0.5, 0.1^2)$, which is slightly more realistic. Finally, the shoe size was modified ranging from European size 36 (U.S. male 4 ½) to 46 (12 ½). All scenarios were repeated 1000 times.

Implementation and statistical analysis

All analyses were conducted with the R software (version 2.15.1). Primary endpoint was the number of steps into a cowpat during the random walk. For each scenario, the mean number of missteps together with the corresponding standard deviation were calculated out of the 1000 iterations. A fixed seed number was used to enable comparability of the different scenarios. To test whether the length of a crossing walk has an impact on misstep frequency, a one-factor ANOVA model was applied to the data [6].

To assess whether a person who is heading toward position R_i hits a cowpat with the *i-th* step, the distance d_{ik} of R_i and each cowpat C_k, $k=1,\ldots,K$, was calculated by the application of Pythagoras' theorem (Figure 1). It was assumed that position R_i reflects the centre of the sole and C_k the centre of the cowpat, respectively, and that both spots can be interpreted as circles. Each cowpat describes a circle with a diameter of 0.3 meters, whereas the R_i circles' diameter depend on the simulated shoe size ranging from 0.278 meters for shoe size 36 to 0.303 meters for shoe size 46. According to this, a step into a cowpat can be observed if $d_{ik} \leq (C_k$-diameter/2)+(R_i^{size}-diameter/2), where R_i^{size} is the diameter at position R_i which depends on the simulated shoe size.

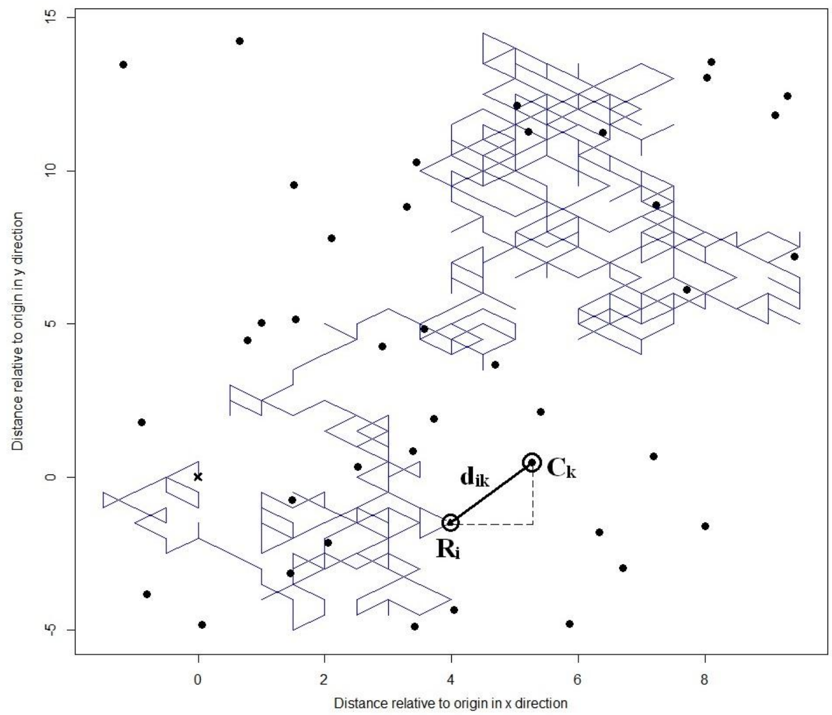

Figure 1: Exemplary random walk with 800 steps and 400 cowpats (bold x: starting point) and illustration of assessing the distance of a particular position R_i and cowpats C_k

Results

The primary hypothesis of an increased number of missteps in case of an extended crossing walk could not be confirmed (p=0.964). The average number of missteps (overall mean of different shoe sizes and step lengths) was 51.6 (SD 33.3) for walks of 400 steps compared to 49.9 (SD 32.3) and 49.7 (SD 32.6) missteps for walks of 800 and 1200 steps, respectively. Overall, scenarios with variable step length showed a lower misstep frequency with a mean difference of 2.8 (SD 2.7), whereas the difference got larger if the number of cowpats was increased. People with smallest investigated shoe size had fewer missteps than those with largest shoe size, in particular the mean differences were 3.3 (SD 0.1), 6.7 (SD 0.3) and 16.7 (SD 0.7) in case of 20, 40 and 100 cowpats. A selected number of simulation runs with large numbers of steps (up to 10,000) revealed that the distinct misstep frequencies show some kind of an asymptotic behaviour and are just marginally smaller than those presented in Table 1.

Table 1: Average number of steps into a cowpat by simulation scenario (arithmetic mean with standard deviation in brackets out of 1000 simulation runs per scenario)

Steps		400 steps		800 steps		1200 steps	
Step length		0.5m	variable	0.5m	variable	0.5m	variable
Cowpats	**Shoe size**						
20	**36**	18.2 (11.6)	18.0 (11.4)	18.1 (12.1)	16.8 (10.5)	17.4 (12.3)	16.4 (10.5)
	38	18.9 (12.0)	18.6 (11.8)	18.7 (12.4)	17.4 (10.8)	17.9 (12.6)	17.0 (10.9)
	40	19.4 (12.3)	19.2 (12.1)	19.4 (12.9)	18.0 (11.1)	18.5 (13.0)	17.5 (11.1)
	42	19.9 (12.6)	19.6 (12.3)	19.8 (13.1)	18.4 (11.2)	18.8 (13.2)	18.0 (11.4)
	44	20.8 (13.1)	20.5 (12.7)	20.6 (13.4)	19.1 (11.5)	19.8 (13.7)	18.8 (11.8)
	46	21.6 (13.5)	21.5 (13.3)	21.5 (14.0)	20.0 (12.0)	20.7 (14.3)	19.6 (12.2)
40	**36**	35.8 (19.1)	35.2 (20.1)	35.9 (19.6)	32.9 (17.4)	34.9 (19.7)	33.5 (18.2)
	38	37.1 (19.7)	36.5 (20.6)	37.2 (20.3)	34.1 (17.9)	36.2 (20.5)	34.7 (18.9)
	40	38.3 (20.4)	37.7 (21.3)	38.3 (20.8)	35.2 (18.4)	37.3 (21.1)	35.9 (19.5)
	42	39.1 (20.6)	38.5 (21.6)	39.0 (21.2)	35.9 (18.7)	38.1 (21.5)	36.6 (19.9)
	44	40.8 (21.3)	40.2 (22.6)	41.1 (22.4)	37.6 (19.5)	39.9 (22.6)	38.2 (20.7)
	46	42.7 (22.1)	42.0 (23.6)	43.0 (23.5)	39.2 (20.2)	41.7 (23.6)	39.8 (21.6)
100	**36**	90.0 (42.9)	87.1 (41.5)	88.5 (42.2)	82.9 (38.1)	89.8 (46.6)	81.8 (37.9)
	38	93.3 (44.5)	90.4 (43.2)	91.7 (43.3)	86.0 (39.3)	93.2 (48.1)	84.8 (39.1)
	40	96.2 (45.8)	93.3 (44.6)	94.6 (44.6)	88.8 (40.5)	96.4 (49.6)	87.4 (40.2)
	42	98.3 (46.7)	95.3 (45.5)	96.5 (45.5)	90.6 (41.4)	98.4 (50.5)	89.2 (41.0)
	44	102.9 (48.8)	99.6 (47.5)	100.9 (47.8)	94.7 (43.0)	102.7 (52.3)	93.4 (42.7)
	46	107.5 (51.0)	104.0 (49.5)	105.3 (49.7)	98.9 (44.9)	106.9 (54.4)	97.6 (44.7)

Discussion

The most surprising result was the negative correlation of the mean number of missteps and the length of a random crossing walk. Although not significant ($p=0.964$), there was the tendency of a decreasing misstep frequency during more extended pasture crossing walks, rather than an initially expected increase in the misstep risk. This finding will make many farmers and hikers who live in close touch with nature quite happy, since it seems unnecessary to pare their strolls down to the minimum to keep the risk of messy shoes preferably small. The comparison of scenarios with fixed and variable step length indicates that it is also beneficial not to have an awkward style of walking since walks with a random step length led to less missteps. Furthermore, in light of the investigated event it could be supposed that people with large feet are disadvantaged since large feet go along with larger shoes which consequently lead to a higher probability of missteps. In fact, this drawback becomes relevant if the number of cowpats is high with a mean difference of 16.7 missteps (SD 0.7).

Limitations

The study's limitations are that the cowpats were assumed to be perfect circular objects, though observations in the wild often indicate a diffuse shape. This may be considered as a source of bias with respect to the estimated misstep frequencies. Moreover, the underlying mathematical model disregards the fact that the crossing walks may depend on somebody's specific arrival point or on the impressions one gets when having a careful look on the next steps, i.e. the walks are in fact not completely random. Especially the latter, of course, could have a substantial effect on misstep frequency.

Conclusions

When crossing a cow pasture not treading warily there is no need to agonise about the beeline since the length of the walk does not affect the risk of stepping into cows' legacies. However, people with large feet have to keep in mind that their risk of a misstep becomes more and more adverse compared to persons with small feet if the number of cowpats increases.

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