

# ASSESSING INDIVIDUAL SPIDER MOVEMENTS

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The validity of invertebrate density assessments using pitfall traps as collection tools has been a persistent and thorny debate. This is especially true for graduate students like me who rely almost exclusively on this collecting method to assess human activities on spider residency or abundance. Spiders, similar to other invertebrates, may or may not move at particular times. The probability of an invertebrate animal crossing the lip of a pitfall trap and then perishing in preservative at the bottom is dependent on its level of activity, thus confounding habitat comparisons. The issue is couched in T. R. E. Southwood's (1966) less-than-inspiring discussion of pitfall traps in his "Ecological Methods: With Particular Reference to the Study of Insect Populations". The recent edition of this ecological bible (Southwood & Henderson 2000) is no more encouraging for students of the pitfall trap. The traditional argument for students like me who cling to our desperate faiths in this method is to blandly state that collections over an entire season quash the variability in catch rates. We then appease our defense committee members by citing Baars (1979), Ericson (1979), Luff (1982), Chiverton (1984), and others. Here I propose an entertaining and complementary argument; a method to assess invertebrate movement as a function of habitat quality. The tools needed to measure movement are a stop watch, a collection of coloured or numbered thumbtacks, string and measuring tape, two sturdy sticks, your favourite invertebrate (in my case *Pardosa moesta* Banks), coloured chalk dust, and a case of beer. This latter tool is essential as shall be seen.

I previously observed, as had many others, that *P. moesta* swarms into gaps in the forest canopy. Consequently, this spider is caught in astounding numbers in the middle of a clearcut and to a lesser extent in the surrounding, uncut forest. One would expect some sort of decay function in its abundance from cut to uncut forest. The traditional method to characterize this decay function is to establish transects of pitfall traps, perpendicular to the hard edge of the forest. However, one can't dismiss the possibility that spiders like *P. moesta* might move at frenzied paces in clearcuts, thus falling into pitfall traps more frequently than sedentary cohorts in uncut forests, all the while maintaining static densities. After a dismal attempt at assessing *P. moesta* preferential movement using directional pitfall traps (moose love to trounce through polyethylene barriers), I decided on a more hands-on, individual-based approach. This meant sacrificing swathes of time

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## UPCOMING MEETINGS

July 24-28, 2003: The 27th annual meeting of the American Arachnological Society at the Denver Museum of Science and Nature, Denver Colorado hosted by Paula Cushing. Registration deadline has yet to be determined. Visit [http://www.americanarachnology.org/AAS\\_Meetings/AAS\\_2003\\_Overview.html](http://www.americanarachnology.org/AAS_Meetings/AAS_2003_Overview.html) for more information. Deadline June 15, 2003.

August 4-9, 2003: 21st European Arachnological Colloquium at St. Petersburg State University in St. Petersburg, Russia. Visit <http://www.european-arachnology.org> for updates.

November 2-5, 2003: Joint meeting of the Entomological Society of Canada and the Entomological Society of British Columbia in Kelowna, BC hosted by Terry Shore. Visit the meeting website at <http://esbc.harbour.com/jam.html> for updates.

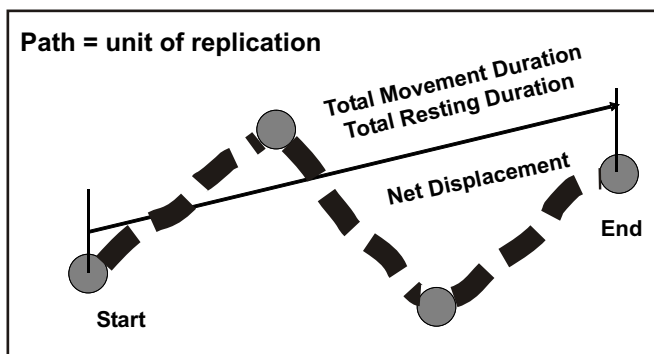
July 12-17, 2004: 16th International Congress of Arachnology in Gent, Belgium hosted by Léon Baert Royal Belgian Institute for Natural Sciences. Visit <http://allserv.rug.ac.be/~jpmaelfa/index.htm> for more information.

tracking individual *P. moesta*, but the outcome has been rewarding because the procedure is simple, the analyses of data are elementary, and the interpretations are palpable. Thanks to Brett Goodwin and Lenore Fahrig's work on goldenrod beetles (2002), I was also guided to supporting literature in this “moving” field of study.

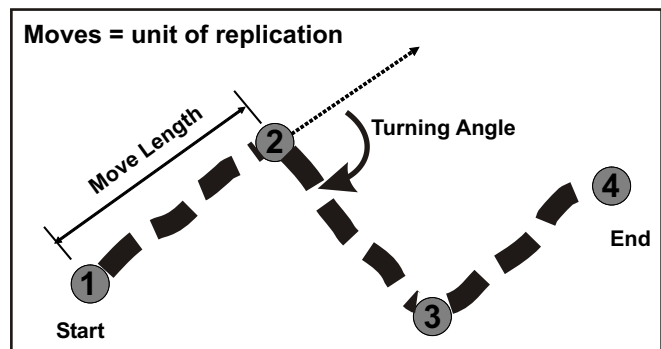
My first step was to individually house and satiate same-sex specimens prior to undertaking field trials. This eliminated the variability in hunger- and gender-specific behaviours. The next step was to establish replicated areas in uncut forest, at the boundary between cut and uncut forest, and in clearcuts, thus permitting robust comparisons of *P. moesta* movement patterns. Individuals were allowed to freely roam in these areas after having had their abdomens dusted with coloured chalk. This was more for me than for them! At every turn in their movement direction, I recorded the time of day and placed numbered thumbtacks while being careful not to disturb their activity or to cast my shadow. The case of beer was important here because the bulk of my time was spent watching immobile spiders. Once a sufficiently long path had been traced, I stopped the census and recreated the movement path. A firmly planted stick at both ends of the path, taut string to measure the distance between each stick and each thumbtack, and a bit of Grade 10 algebra were the only requirements to measure the distance moved between turns, the intervening turning angles, and ultimately, a recreation of the path on a spreadsheet.

I had three working hypotheses. First, *P. moesta* in clearcut stands should move quickly in short bouts and turn frequently. These short movement bouts and frequent turns would result in low net displacement, or increased residency. Second, *P. moesta* in uncut forest (buffer) should move slowly in long bouts with infrequent turns. This would result in directionality to their movement, presumably toward better feeding grounds perhaps like that found in the clearcut. Third, *P. moesta* at the boundary between uncut forest and clearcuts (edge) should have intermediate movement bouts, speeds, and turns.

There are two facets to these hypotheses, dependent on how one dissects the movement paths or wishes to make habitat comparisons. The first considers paths traced by spiders in each habitat type as the unit of replication (Figure 1) and the other considers the components of a path, i.e. the unique movement lengths and intervening turning angles as the unit of replication (Figure 2). The former permits comparison of overall displacement in different habitat types and the latter permits fine-scaled comparison of bouts of speed and turning frequency. Replicates of paths are easier to work with than replicates of moves. There is a chance that each successive move is dependent on the previous move. To be confident that moves and turning angles are independent replicates, you have to examine autocorrelation functions for each spider's path (not shown).



**Figure 1.** Components of a typical path traced by *Pardosa moesta* Banks. Paths are the units of replication when calculating net squared displacement, total path length, and total time spent moving or resting.

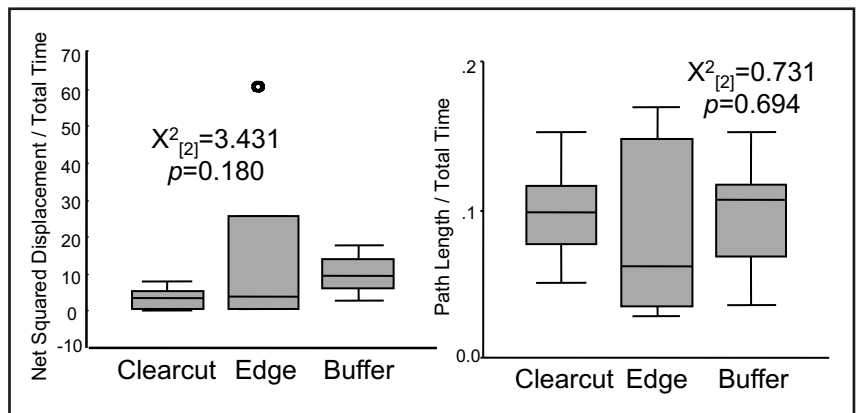


**Figure 2.** Components of a typical move traced by *Pardosa moesta* Banks. Moves are the unit of replication when calculating move lengths and turning angles once autocorrelation functions are examined (not shown).

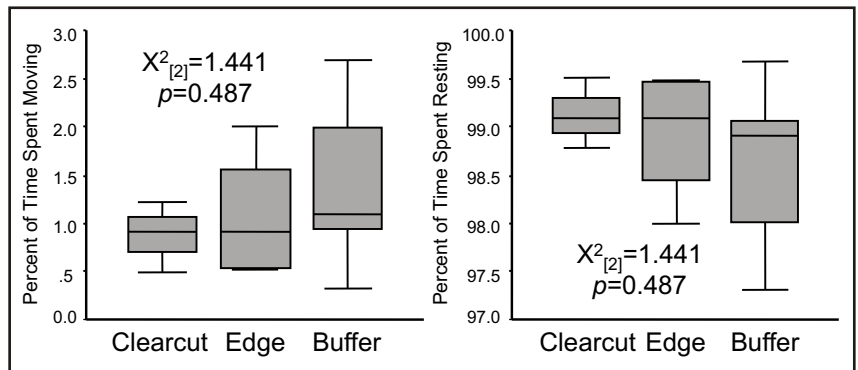
As it turns out, there is no statistical difference between net squared displacements (the traditional way of reporting displacement) or total path lengths between the three habitat types (Figure 3). Nor is there any statistical difference between the total times spent moving or resting between these habitats (Figure 4). Consequently, there shouldn't be any observable mass effect of adult *P. moesta* populations when the forest is cut. However, there may indeed be mass movement of immature *P. moesta* either via ballooning into canopy openings or movement on the ground from adjacent, closed canopy stands. These possibilities might explain the incredible abundance of *P. moesta* in freshly cut stands, but we can rule out the possibility that this is due to the movement of adults.

Fine-scaled movement patterns are a little more complicated and at first glance conflict with the above assessment. During individual bouts of movement, *P. moesta* moves faster, rests longer, (Figure 5), and covers greater distances (Figure 6) in clearcut stands than in either uncut stands or at the boundary between these two habitat types. However, individuals chase their tails more often in clearcuts by frequently doing about-faces and scampering off in the opposite direction (Figure 7). The net result is that total times spent moving and resting and total path lengths and net displacements between spiders in clearcut stands, uncut forest, and the boundary between the two are indistinguishable.

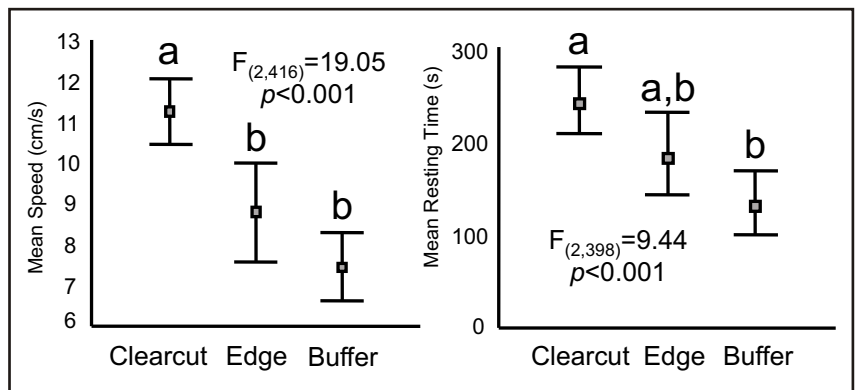
**Figure 3.** Box-whisker plots of *Pardosa moesta* Banks net squared displacements and total path lengths as a function of total time in clearcuts, uncut stands (buffer) and at the boundary between the two stand types (edge).

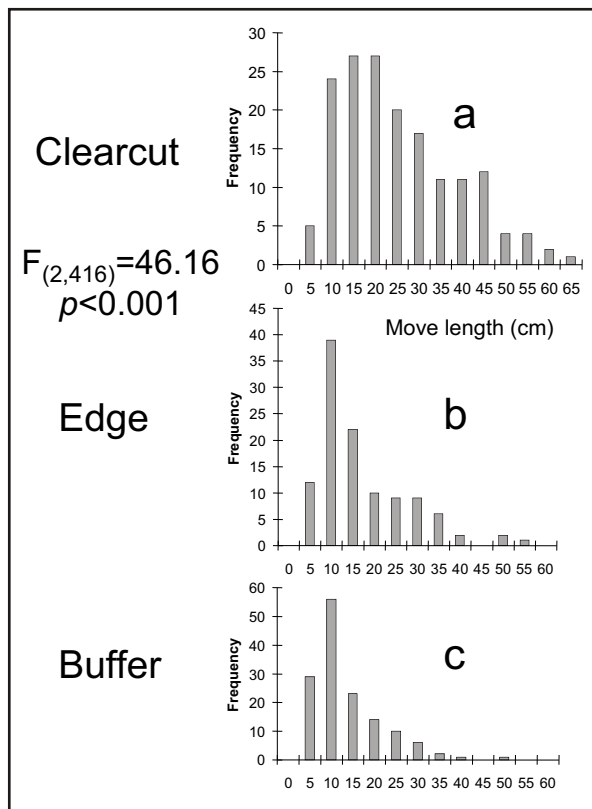


**Figure 4.** Box-whisker plots of *Pardosa moesta* Banks percent time spent moving or resting in clearcuts, uncut stands (buffer) and at the boundary between the two stand types (edge).

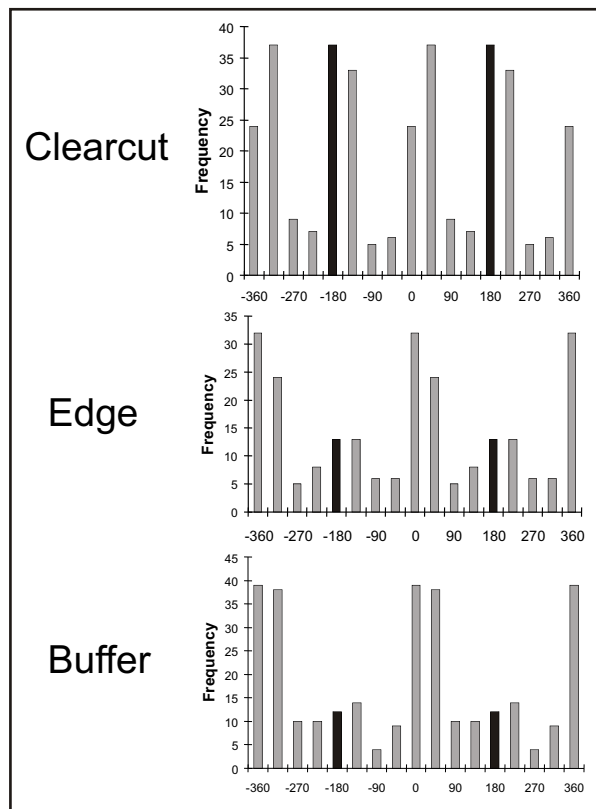


**Figure 5.** One-way analyses of variance in *Pardosa moesta* Banks move speeds and time spent resting between each move in clearcuts, uncut stands (buffer) and at the boundary between the two stand types (edge). Letters designate highly significant differences ( $p<0.001$ ) in move speeds or time spent resting between the three stand types.





**Figure 6.** Frequency distributions of *Pardosa moesta* Banks move lengths in clearcuts, uncut stands (buffer) and at the boundary between the two stand types (edge). Letters designate highly significant differences ( $p<0.001$ ) in move lengths between the three stand types.



**Figure 7.** Wrapped frequency distributions of *Pardosa moesta* Banks turning angles between moves in clearcuts, uncut stands (buffer) and at the boundary between the two stand types (edge).  $0^\circ$  and  $360^\circ$  indicate movement in the forward direction and  $180^\circ$  indicates a reversal of direction. Negative values indicate turns to the left and positive values indicate turns to the right.

What does all this mean for those of us who rely on pitfall traps for assessing the impact of human activities on invertebrate populations? The traditional and long-standing argument about trapping over an entire season in order to smooth out the variability in short-term trapping now holds more water. Because individual movement bouts of *P. moesta* are highly variable across a landscape of variable habitat structures, one would expect differing probabilities in catch rates and thus an inaccurate assessment of population density. This is especially true if the goal is to compare catches/densities between closed and open canopy habitats. However, because the overall path lengths and displacements traced by *P. moesta* are similar between habitat types, extending the trap season will eliminate this confounding source of variability.

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## **MY EXPERIENCES CONDUCTING RESEARCH IN NORTH SULAWESI, INDONESIA**

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I recently returned to Edmonton, Alberta to complete my Ph.D. thesis on the diversity of spiders in the cacao agroforests of North Sulawesi. I'm a native of that part of the world, so it was a wonderful opportunity for me to spend two years conducting spider research in my parents' hometown of Manado, North Sulawesi. Originally I had hoped to conduct this research in Southeast Sulawesi, the location of my home university. However, because of the political unrest in that part of Indonesia it was necessary to conduct my work in a safer place. My work has been sponsored by the Eastern Indonesia Universities Development Project, a project supported by the Canadian International Development Agency.

I spent the last month of the new millennium under the blazing sun, selecting study sites within four types of cacao agroforests that represent the typical gradient in cacao agroforest strategies in North Sulawesi. These ranged from pure monocultures to mixtures of cacao and other trees. It is assumed that the greater diversity of trees in the agroforestry stand types will provide the necessary structure to maintain generalist predator populations, thus minimizing the dependency on costly insecticides. However, the efficacy of these mixed stand strategies for pest management and for biodiversity protection is not known. In my Coconuts-Glyricidia-Cacao forest type, I established one site in Kima. This particular site is a 4 ha private cacao estate consisting of 17 years cacao, 13 years Glyricidia, and 40 years coconuts, 13.6 km from campus. The other one was in Pungkol that is the Coconuts-Glyricidia-Cacao type and the Glyricidia-Cacao type, 35 km from campus. It's a 600 ha private cacao estate with 10 years cacao, 12 years Glyricidia, and 10 years coconuts. Later on I was able to find two more sites, Paniki for the Coconut-Glyricidia-Cacao type, and Tiniawangko for three types; the Glyricidia-Cacao type, the Cacao Monoculture type, and the Natural Shade Trees-Cacao type. The first one is a 1.8 ha private cacao estate with 15 years cacao, 13 years Glyricidia, and 40 years coconuts, 10 km from campus. The second one is a 50 ha state cacao estate and 200 ha coconuts, about 150 km from campus.

I installed and maintained pitfall traps, and used a sweep net to sample the trees and the ground for spiders every other week in each of my nine sites. There was one site in Kima (the Coconuts-Glyricidia-Cacao I), one site in Paniki (the Coconuts-Glyricidia-Cacao II), three sites in Pungkol (the Coconuts-Glyricidia-Cacao III, the Glyricidia-Cacao I and the Glyricidia-Cacao II which were apart about 12 km with different elevation), and four sites in Tiniawangko (the Glyricidia-Cacao III, the Cacao Monoculture I and the Cacao Monoculture II which were apart by the main road and the Natural Shade Trees-Cacao). Therefore I was able to sample three replicates for the Coconuts-Glyricidia-Cacao, three replicates for the Glyricidia-Cacao, two replicates for the Cacao Monoculture, and only one replicate for the Natural Shade Trees-Cacao. That's the best I could achieve in North Sulawesi with regards to time, budget, safety reason for conducting the research, and permission from the owners to conduct my research in those sites.