Carnivore diversity, distribution and quality comparison of digital and 35mm field cameras on the University of Notre Dame Environmental Research Center.

BIOS 35502: Practicum in Environmental Field Biology

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Abstract:

Carnivores drive natural selection and through predation modify behavior of prey. They are an important roll in forest ecology. Specifically american fisher and marten are sensitive mes-carnivores, that because of their sensitivity can be good indicators of forest quality and forest ecosystems. UNDERC has been logged as recently as 1970. This logging may still be affecting these populations of meso-carnivores. The survey had the goal of detecting the presence of these specialized carnivores. The track plate survey and camera trap survey and comparison ran for most of the summer. After all data was collected at the end of the summer tests were performed calculating visitation index and latency for each species and each type of box. Camera comparisons failed because of 35 mm camera failure.

Introduction:

Carnivores play an important role in forest ecology. Their presence can drive natural selection, and through predation modify the behavior of prey. The American fisher *(Martes pennanti)* and marten (*Martes americana)* are habitat specialists and sensitive meso-carnivores, dependent on serpentine habitats that provide low brush cover (Slauson 2003). Because of their sensitivity to habitat disturbance fisher and marten can be good indicators of forest quality and good indicators of forest ecosystems (Buskirk and Zielinski 2003).

Treatment of meso-carnivores by humans has been dominated by trapping and habitat destruction. Trapping and habitat destruction, mostly by logging, has severely affected the meso-carnivore population to the point of large loss in numbers or even extinction in certain habitats or regions. Fisher and marten have especially declined in numbers due to the desire for their furs (Zielinski 1995).

The University of Notre Dame Environmental Research Center (UNDERC) has been logged as recently as 1970. Historic logging practices might continue to influence meso-carnivore distribution and population density among different habitats. The current distribution of these species is not known for UNDERC. While previous track plate based surveys failed to detect meso-carnivores, camera trap evidence documented their presence a few years ago. To better evaluate whether these species are still present, and if so, determine their distribution I conducted a survey of the property specifically for meso-carnivores. I used modified track plate stations throughout the UNDERC property, stratified by three dominant vegetation types: maple, mixed-coniferous and mixed-deciduous forest.

The main targets for this survey included the American marten, fisher, raccoon (*Procyon lotor),* and mink on the UNDERC property. Detection of other large carnivores, black bear (*Ursus americanus)* and coyote (*Canis latrans*) is possible, but may not provide independent information on distribution across the property, because the same individuals may visit all track stations due to large home ranges.

To conduct this survey, toner-coated track plates along with camera traps were distributed throughout UNDERC to detect carnivores through identification with tracks or photographs. Observed distribution of tracks were compared differences between box types and cameras to obtain frequency of species and time until detected.

In addition I conducted an experiment with the camera traps to test the relative efficiency of 35 mm and digital cameras for detecting meso-carnivores, using both types of cameras in three different locations. Cameras have proven effective before for the detection of carnivores in many areas (Kellam 2003). Despite this previous success and prior photographic capture of fisher on the UNDERC property, last year's surveys failed to detect this species. This may mean that the species is no longer present or that the species was present but the survey failed to detect it. Cameras are very useful for the detection of animals that are more active during nighttime hours when it would be difficult for observation. They are also useful in observing animals without resulting in human disturbance from direct observation in the woods. I believe that both boxes and cameras will be successful in capturing evidence of carnivores. Depending on variables like weather conditions, the cameras may be a bigger asset in identifying carnivores on the property. For the camera comparison, I believe the digital camera may be more cost effective, but may not produce better pictures.

Materials and Methods:

UNDERC is an approximately 7500 acre northern hardwoods forest on both sides of the state line between Wisconsin and Michigan's Upper Peninsula. It includes a land area of 6150 acres and 30 lakes and bogs. Access to the property is strictly controlled with locked gates and restrictions on all roads. Strict guidelines also govern all on the property. The Ottawa National Forest borders this private land on three sides.

Carnivore Track Plate Survey:

I surveyed the property for meso-carnivores using toner coated track plates enclosed in weatherproof boxes (Zielinksi 1995). This reduced the loss of data due to weather conditions. The large (provide dimensions) and small (provide dimensions) track plates consisted of galvanized steel coated with black printer toner. The 12 smaller boxes of cameras in three different locations. Cameras have proven effective before for the detection of carnivores in many areas (Kellam 2003). Despite this previous success and prior photographic capture of fisher on the UNDERC property, last year's surveys failed to detect this species. This may mean that the species is no longer present or that the species was present but the survey failed to detect it. Cameras are very useful for the detection of animals that are more active during nighttime hours when it would be difficult for observation. They are also useful in observing animals without resulting in human disturbance from direct observation in the woods. I believe that both boxes and cameras will be successful in capturing evidence of carnivores. Depending on variables like weather conditions, the cameras may be a bigger asset in identifying carnivores on the property. For the camera comparison, I believe the digital camera may be more cost effective, but may not produce better pictures.

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I surveyed the approximately 20 km^2 of terrestrial environments on UNDERC, by placing pairs of one small box and one large box 0.5 km apart in in 1km^2 grids. The previous carnivore study conducted on the UNDERC property compared the effects of vegetation types on trap success. No correlations between detection success and vegetation type (Lemmon, unpublished) were found. Consequently, I did not expect that vegetation type would influence detection rates; however, to be certain, I stratified my sampling by placing 2 boxes in each of last year's grids stratifying according to the three dominant vegetation types.

The track plates were placed out at the same time and monitored throughout the summer every three days from June 12th until July 16th. I recorded the number of detections of each species and calculated a visitation index as the number of detections per number of operable station nights, $V=a/n$, where V represents the index value, a is the number of detections for a species, and n is the number of nights of observations.

Track plates were baited with Craven's Gusto trapping lure (Craven's Minnesota Trapline Products, Pennock, MN). In addition to the Gusto lure, the track plates were baited with chicken legs or gizzards for a period of 12 days.

Camera Trap Test/Survey:

I tested for differences in the cameras' picture quality and timing, if one camera reacts quicker to the sensor, reducing missed photos. This will help to determine which type of camera will be better for certain studies. The camera traps have two cameras, one of each type at three sites and baited with fish carcasses and deer carcasses. The sites were separated from the track plates and run for a total of 38 days. The pictures were time stamped to record when individuals visited a station.

Stations with camera traps can tell us more than what we find from the track plates alone. With the two types of cameras I looked at the relative efficiency of both cameras. Even though three camera stations were employed, they provided photographic evidence that was not detected at the track plates. This is a smaller sampling size and was not be used exclusively for detection of all species. The data collected using the camera traps augmented the track plates by providing visual evidence of species that the track plates did not detect. The cameras recorded the time bait stations were visited and by what species of carnivore. These data helped to determine if habitat or visitation of a carcass or specific pile of bait affect the visitation time of other carnivores.

Analyses

For each species detected using track plates, I tested for differences in either visitation rates or latency to detection between box sizes. I had two categorical variables species and box type along with two dependent variables, latency until detection and visitation index. Latency, is how many days until first a species was first identified. Visitation index was calculated by the total number of visits divided by total number of check multiplied by a thousand. I planned to use 2-Way ANOVAs for analysis, however due to normality issues I employed the nonparametric ANOVAs, Kruskal-Wallis and Mann-Whitney followed by Tukey post hoc contrasts. I used a sample size of 12 and used each grid as a replicate for comparing detection methods on the property. For some species the observations may not be independent, so inference is restricted to the property.

The cameras were tested in two different ways. The sample size will be the three cameras. For the index of species a comparison of the number of photos for a given species will be compared with the number of total photos using a t-test. The pictures will also be time punched so that you can overlay same species pictures to try and find a time relationship. I planned to compare both camera types in terms of efficiency and quality. The 35mm camera was unsuccessful in taking any pictures. I was only able to compare the digital camera captures qualitatively with the track plate data. Latency was also recorded for species captured on the digital camera. All statistical tests will be done using SYSTAT 12 (San Jose, California, USA)

Results:

Track plate survey

During the 36 day sampling period for large and small enclosed track plates a total of six species visited the boxes on 79 occasions. Species identified were black bear, raccoon, porcupine (*Erethizon dorsatum*), red squirrel (*Tamiasciurus hudsonicus*), and deer mice (*Peromyscus sp.*). Visitation indices for each box type did not fit a normal distribution (Komolgorov-Smirnov 1-Sample fit, $P<0.001$), and efforts to transform the data were unsuccessful. Because the data suggested a Poisson distribution even though the fit was poor (Kolmogorov-Smirrnov fit $P<0.01$), I fit a log linear model using a Poisson distribution; however, residual diagnostics demonstrated a lack of improvement. Consequently, Kruskal-Wallis and Mann-Whitney non-parametric tests were used to compare visitation rates among box types and species. Separate analyses were conducted for carnivore and rodent species. For the predators, mean visitation rate differed significantly between bear and raccoon for small boxes (Mann-Whitney U=17.00, P=0.01 df=1), but not for large boxes (Mann-Whitney U=58.500, P=0.377 df=1). (see figure 1). For black bear no significant difference was found between small and large boxes (Mann-Whitney U=83.00, P=0.402 df=1); however, for raccoon visitation rate differed significantly between small and large boxes (Mann-Whitney U=37.00, P=0.033 df=1). Similar tests and comparisons were conducted for the rodents, *Peromyscus sp.*, red squirrel, and porcupine. For each rodent species, there was no difference in mean visitation rates between large and small boxes (deer mice: Mann-Whitney U=67.500, P=0.785 df=1; red squirrel: Mann-Whitney U=52.500, P=0.185 df=1; and porcupine: Mann-Whitney U=72.500, P=0.952 df=1). The comparison across all three species for the large box type showed significance (Kruskal-Wallis=12.311, P=0.002, df=2). Using post hoc non-parametric Tukey contrasts, there was a significant difference between deer mice and porcupine (q>3.314, P<0.05), but no significant difference between porcupine and red squirrel or red squirrel and deer mice (q<3.314, P>0.05). Similarly, mean visitation rates differed significantly among rodents for the small boxes (Kruskal-Wallis=11.653, P=0.003, df=2). Using post hoc Tukey contrasts, there was a significant difference between deer mice and porcupine (q>3.314, P<0.05), but no significant significance between porcupine and red squirrel or red squirrel and deer mice (q<3.314, P>0.05) (see figure 2).

As for the visitation indices, the same normality tests and evaluation using log-linear models yielded similarly poor fits to normality or a Poisson distribution for the latency to detection values. Consequently, Kruskal-Wallis and Mann-Whitney non-parametric tests were also used to test the significance among species and box type with respect to latency to detection (LTD). For each of the five species, mean LTD did not differ between large and small box types (bear: Mann-Whitney U=86.00, P=0.286, df=1; raccoon: Mann-Whitney U=81.000, P=0.592, df=1; deer mice: Mann-Whitney U=87.000,

P=0.378 df=1; red squirrel: Mann-Whitney U=87.500, P=0.303 df=1; and porcupine: Mann-Whitney U=71.500, P=0.952 df=1). However, for both carnivores and rodents, species differed in mean LTDs at both box types (see figure 3 and 4). LTD's for all rodents showed significant difference between the large boxes (Kruskal-Wallis=10.941, P=0.004, df=2). Using post hoc Tukey contrasts, there was a significant difference between the deer mice and porcupine (q>3.314, P<0.05), but not between the porcupine and red squirrel or red squirrel and deer mice (q<3.314, P>0.05). The Kruskal-Wallis test comparing the mean LTD's for all rodents showed significant difference between the small boxes. (Kruskal-Wallis=8.399, P=0.015, df=2). Deer mice and porcupine differ significantly in visitation rates (Tukey contrasts: q>3.314, P<0.05), but porcupine and red squirrel or red squirrel and deer mice do not (q<3.314, P>0.05). Mean LTD's for large boxes did not differ significantly between predators (Mann-Whitney U=42.00, P=0.068, df=1). The small box comparison, however, showed a significant difference between bear and raccoon (Mann-Whitney U=39.00, P=0.027, df=1).

Cumulative frequency curves for each species for both large and small boxes were plotted over the 36 day sampling period. Black bear were detected at small boxes shortly after the boxes were set and did not visit them again in the sampling period. The large boxes had a more consistent curve, they were visited for the duration of the sampling period (see figure 5). For raccoons, the large box showed evidence of visitation from the beginning until the end of the sampling period. Once discovered, the small boxes were visited throughout the survey (see figure 6). Deer mice visitation at both boxes occurred in a similar fashion over time for both box types. Once detected on day 12 they showed signs of visitation throughout the study. Porcupine had a total of three visits. One visitation on the small box type and two visitation for the large box type These three visits were during the first and last week of the sampling period. Red squirrel visitation at both boxes occurred in a similar fashion over time for both box types. The small box was discovered faster than the large, but similar frequency during the duration of the test.

Camera trap survey:

The camera trap comparison between 35 mm cameras and digital field cameras was unsuccessful. Of the nine rolls of 35 mm film that were developed from throughout the summer, only nine pictures were exposed. Of those nine photographs there were no animal detections in the pictures. By comparison, the digital cameras captured 385 images, including carnivores such as, fisher .33 ± value (mean ± SE), coyote 1 ± value (mean ± SE), bear 2.66 ± value (mean ± SE), bobcat .33 ± value (mean ± SE), and raccoon 5.33 ± value (mean ± SE).

Discussion:

This meso-carnivore survey throughout UNDERC had the objective to identify carnivores on the property, but specifically the two that are in question of existence, marten and fisher. These observations helped to give an idea of effectiveness of each box size due to frequency curves and a general idea of LTD. Visitation rate to boxes was highest for deer mice and raccoon with an average of 2.63 ± value (mean ± SE) visits per trap check. The only other target species detected at track plates were black bears, with an average of 0.727 ± value (mean ± SE) visits per box check. The two target species, American marten and fisher, were not detected on the closed track plates. This lack of detection may be due low densities of the species along with their larger home ranges compared to that of a raccoon that had a high visitation numbers. Another explanation could be that marten and fisher are trap shy in comparison to other species. This may not be the case, though, since track plates have been used effectively for detection of fisher and marten (Zielinski et al. 2005). In addition to these two species, several target species were only detected using digital cameras: coyote, fisher, and bobcat.

Surprisingly, box size did not influence detection of black bears. No actual test on preference was done because I could not run a true preference trial, because no evidence if any boxes were simply looked at by bears and left undisturbed. This study does suggest how effective the relative box types were as a means of detecting bear presence through enticement to leave sign. A bear is a fairly large animal and even the large box would have trouble fitting such an animal. Many of the bear detections resulted from destruction or dismantling the boxes rather than entry or reaching into the boxes for the bait. The detection rate for bears was inflated due to the use of track box destruction as an indication of a species' presence. This is an option that is primarily available to bears, which would not be available to smaller, possibly neophobic species, that would visit a box but not leave any sign, thereby reducing detection rates an LTD's for those species. The small boxes seemed more effective at collecting tracks. It is possible that the raccoons could obtain more information about a large box's contents without entering than for a smaller box. Also, predator distribution and encounter rates could influence detection rates. Neither box sized was more effective with rodents. However, for both large and small boxes deer mice had significantly higher visitation rates than porcupine and red squirrel. Mice may have not preferred either box type because the size of the box would not limit entry of mice, as a small box might hinder access by a bear.

There was no difference between large of small box visitation number for deer mice and red squirrel, which may again reference back to the size of the animal. Those two are both small rodents. However, the porcupine had the lowest time until it was detected and was different from the other two rodents. Among rodents as a whole box size did not have an effect when testing for latency until detection. The only difference among the predators was recorded in the small boxes. The bear was detected more quickly than the raccoon to the smaller boxes. The detection rate for bears was inflated due to the use of track box destruction as an indication of a species' presence.

There were many sources of error encountered during the sampling period, many of which were fixed, but may have altered the final data. The first and most detrimental problem was the excessive presence of carrion beetles at all track plate boxes. Initial baiting with chicken pieces as in prior studies resulted in attraction of numerous carrion beetles, which subsequently hindered track detection. This meat attracted the carrion beetle to the box, which would ruin each trap check. The beetles either consumed or removed by walking across, all of the black toner, leaving no marker for a carnivore to leave tracks. The beetles then also walked across the contact paper obscuring detection of any possible tracks. The carrion beetle problem was remedied by discontinuing the use of meat bait, which eliminated beetle infestations at boxes immediately. Meat was removed and only scent lure was used for baiting. The excessive beetle presence may have affected latency time, by delaying the first detection of a species at a box. This seems likely because many species were detected immediately once the beetles were no longer present. This is also evident in the similar 14 day latency time across species. The early detection of porcupine was assisted by additional sign left at boxes, such as quills and feeding patterns on the boxes. Finally, damage to boxes might have influenced detection rates by precluding the detection of sign subsequent to the box damage. Even though black bear presence could still be detected if a bear dismantled the station, other species might not then be detected

The lack of camera comparison data was caused by faulty film spooling, loading, and rewind mechanisms prevented successful detections with the 35 mm cameras (Stealth Cam Bedfored, Tx) Other 35 mm systems might still work better than the digital, and would need to be tested. For example Camtrakker, and Trailmaster make 35 mm, but they are considerably more expensive than the units I used.

Acknowledgments:

I would like to thank Dave Choate for mentorship, wisdom, and time and effort throughout the project. Also thanks to Libby Whiting for help setting traps and Dano Heatwole for carrying around deer carcasses. Thanks to Gary Belovsky and Michael Cramer for their help and allowing me this opportunity. Finally, thanks to the Hank family for providing this wonderful place for undergraduate studies.

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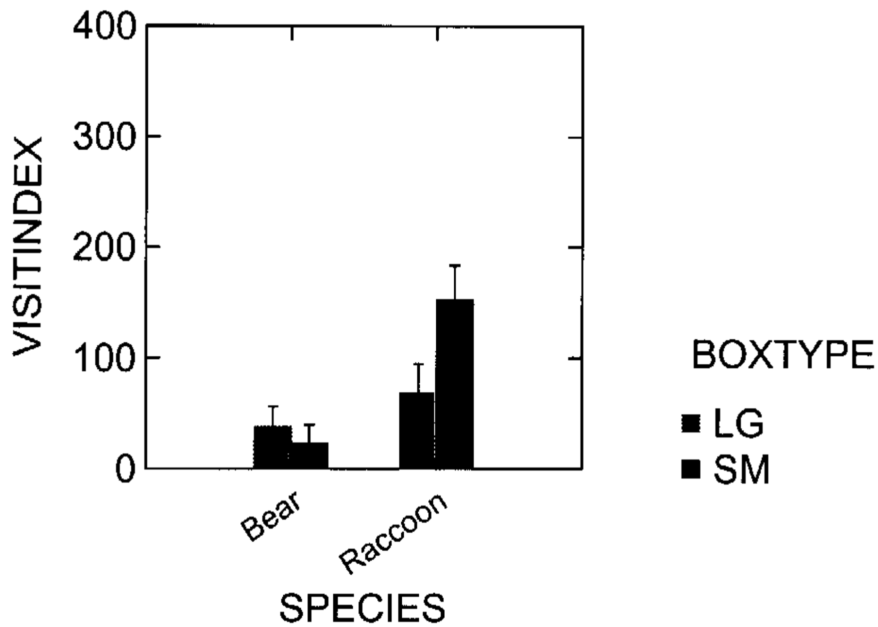

Figure 1: Mean visitation index (± SE) for bear and raccoon for small and large boxes. Bear visitation at smaller boxes was significantly less than raccoons at smaller boxes (Mann-Whitney P=0.01). Raccoon visitation was higher for small boxes than large (Mann-Whitney P=0.033).

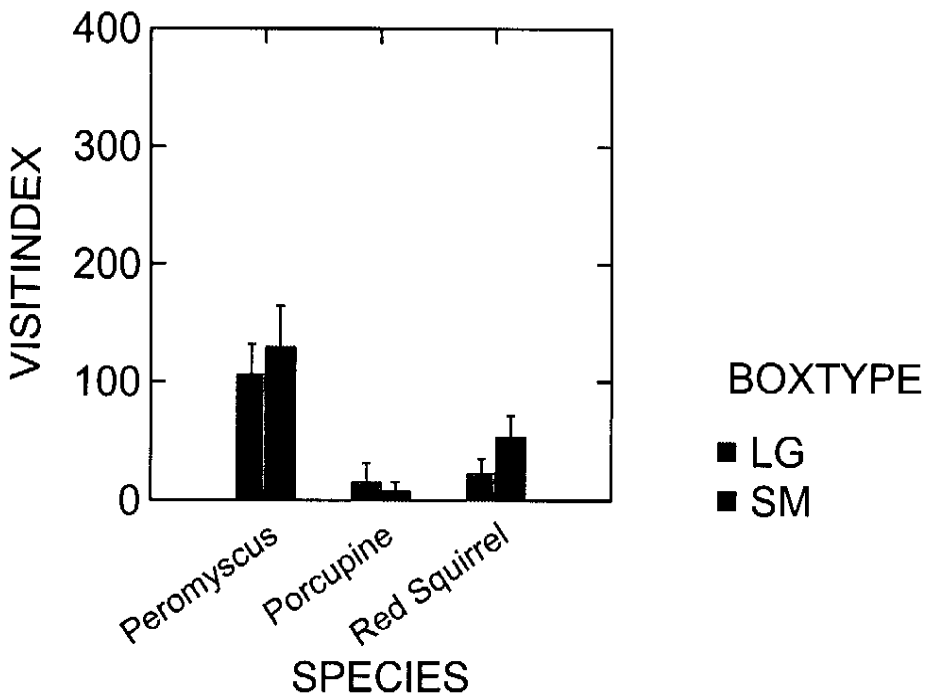

Figure 2: Mean visitation index (± SE) for three rodent species for small and large boxes. Visitation for three species differed across large box types (Kruskal-Wallis P=0.002). Tukey post hoc: significant difference between deer mice and porcupine (q>3.314, P<0.05).

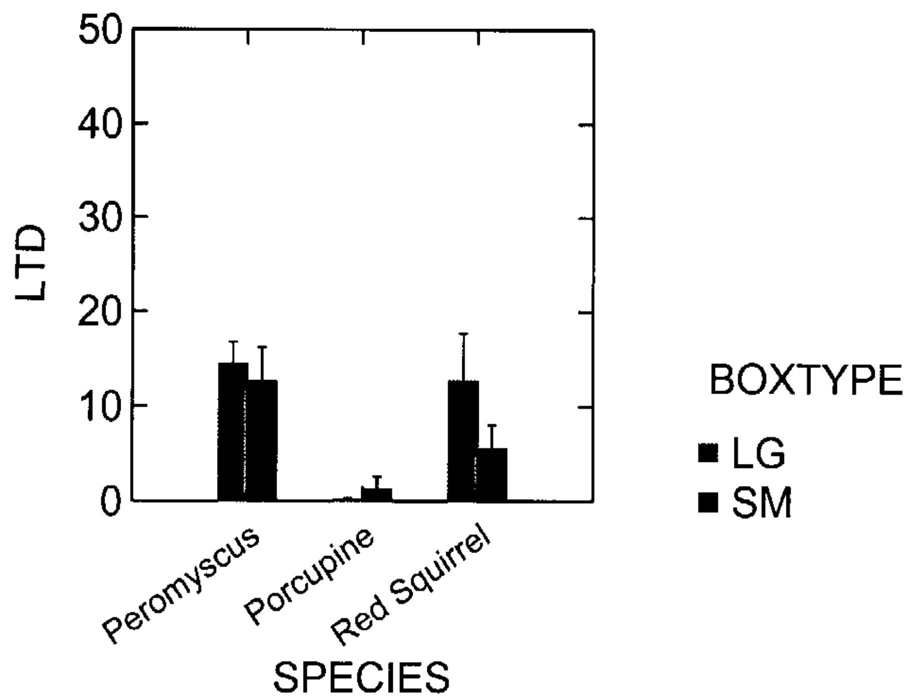

Figure 3: Mean latency until detection (± SE) for three rodent species for small and large boxes. LTD's for three species differed across large box types (Kruskal-Wallis P=0.004). Tukey post hoc: significant difference between the deer mice and porcupine (q>3.314, P<0.05)

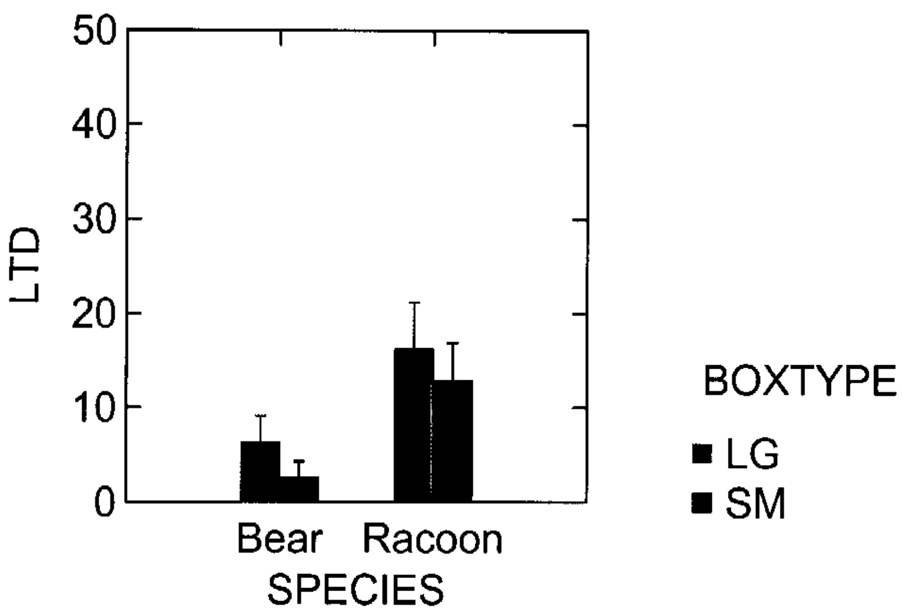

Figure 4: Mean latency until detection (± SE) for bear and raccoon for small and large boxes. Bear LTD's at smaller boxes was significantly less than raccoons at smaller boxes (Mann-Whitney *P*=0.027).

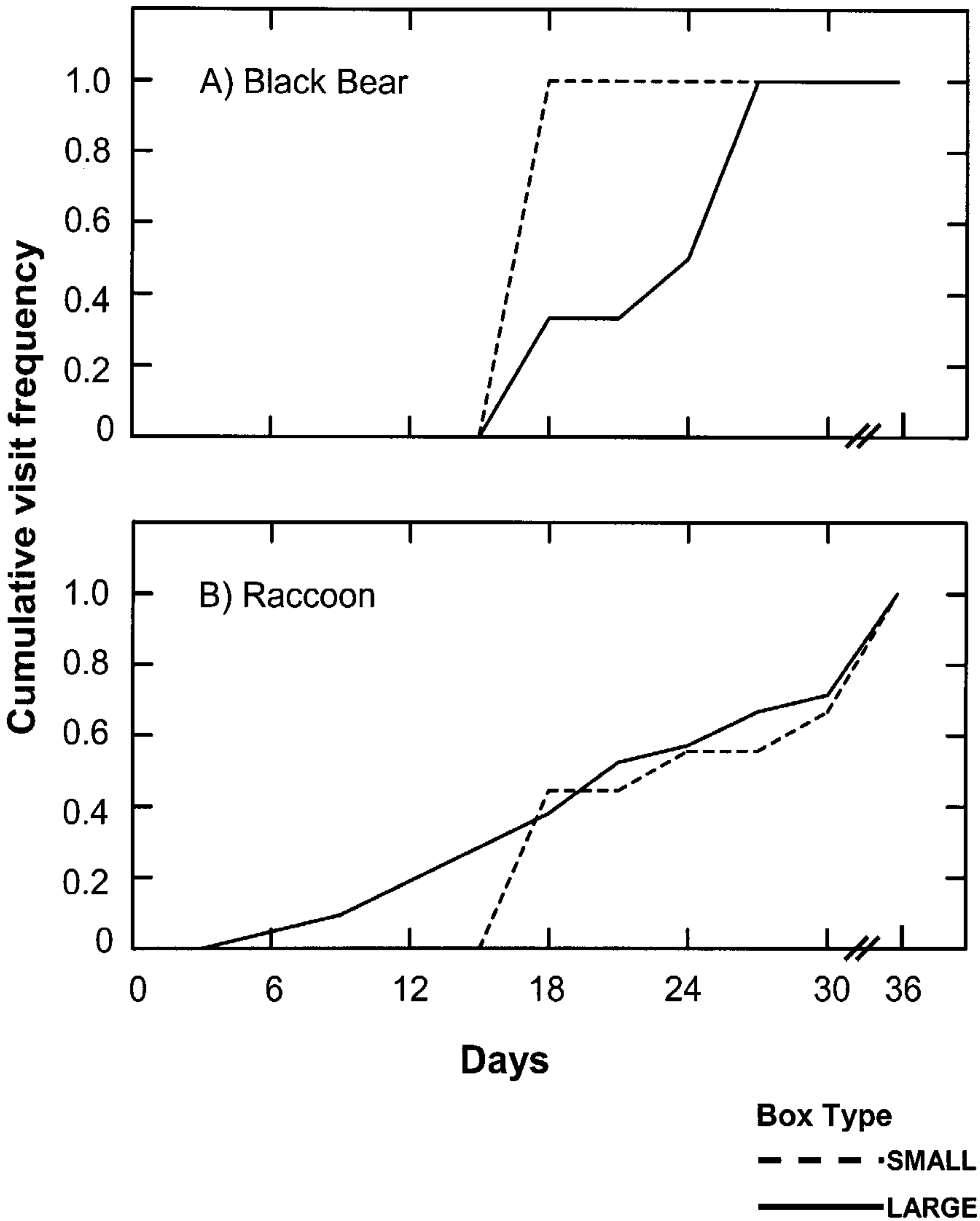

Figure 5: Visitation index= total number of visits for a given box type/ total number of trap checks X 1000. The index shows the mean value of how many visits per day for a given species

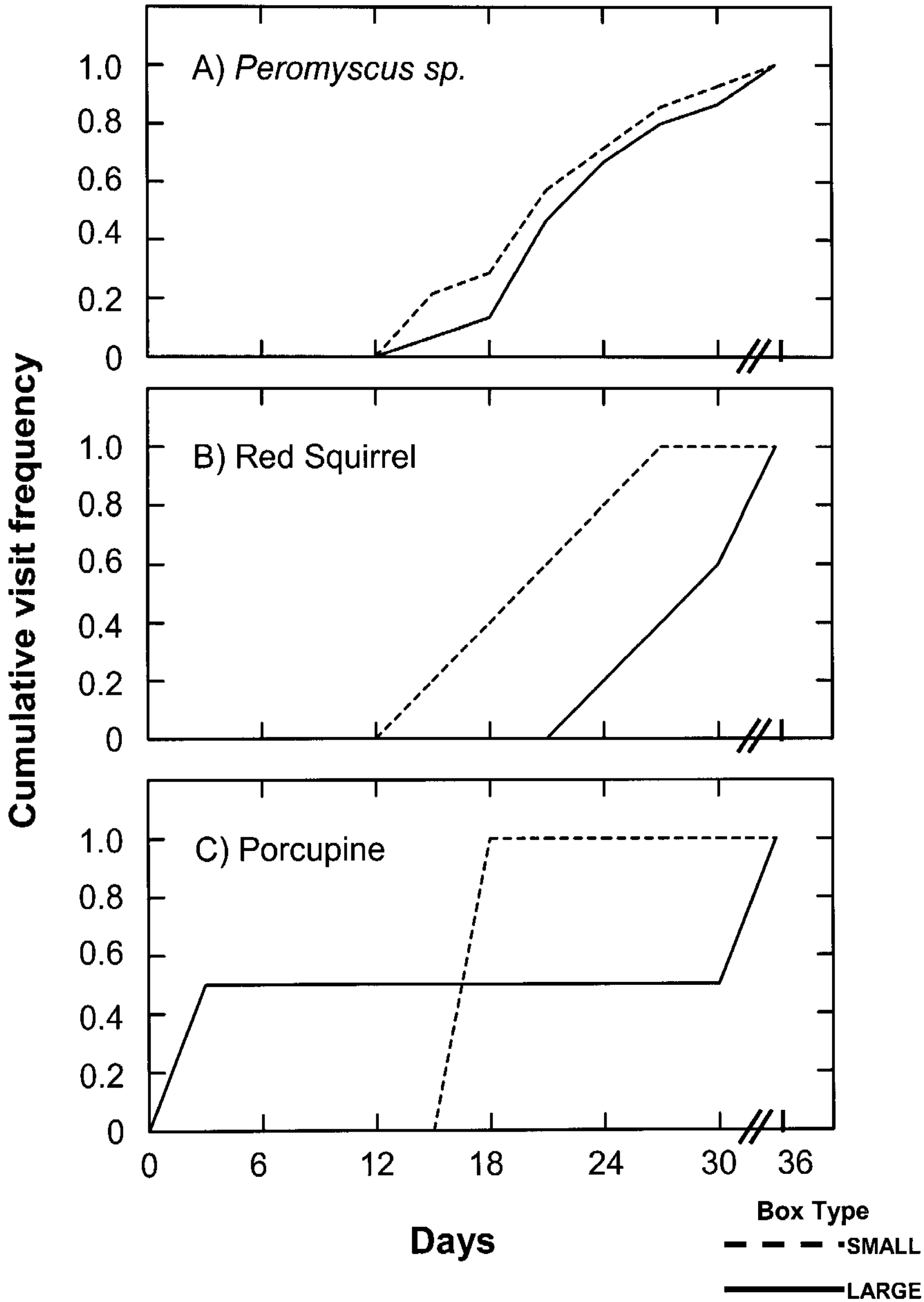

Figure 6: Visitation index= total number of visits for a given box type/ total number of trap checks X 1000. The index shows the mean value of how many visits per day for a given species