Individual identification and extracting risk areas for reducing damage by the Japanese black bear (*Ursus thibetanus japonicus*) in the Satochi-Satoyama of Gunma Prefecture, Japan

Summary of Doctoral Thesis

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The Japanese black bear (*Ursus thibetanus japonicus*) is large wildlife, and distributed on the islands of Honshu and Shikoku in Japan. In recent years, conflict between human and bears has occurred mainly in the Satochi. The damage by bears in the Satochi has been concerned about the involvement of individuals attached to Satochi (hereinafter, [urban bear]). However, the actual condition of urban bear is not clear. Therefore, in this study, we investigated the status of each bear that inhabited the Satochi using individual identification at Numata City, Gumma Prefecture, for the purpose of elucidating the actual condition of urban bear. Furthermore, based on the actual condition of bears that could be clarified by individual identification, we extracted the risk areas (hereinafter, [RAs]) where the danger of intrusion of bears is high, for the purpose of proposing effective measures in the Satochi. From these results, we expected to contribute to reducing the damage by bears in the study area.

In Chapter 2, we understand the status of each bear that inhabited the Satochi using individual identification by camera-trapping method. We identified individual bears by the chest marks from the photographs taken with camera traps from 2012 to 2013. As a result, we identified 21 bears (16 bears in 2012, 9 bears in 2013, the same 4 bears in two years).

We assumed that the population density of bears in autumn of 2013 was relatively low, based on the frequency with which bears were taken, the mean number of identified individuals when the survey period was divided into the former term and the latter term from the beginning of September of each year, and the number of new individual bears in the latter term. That reason was that the hard mast production in autumn of 2013 was good.

Based on the length of period during which inhabitation could be confirmed, we classified individuals into resident bears and transit bears. As a result, there were 6 resident bears and 19 transit bears in two years. Also, 3 resident bears of 4 bears identified for two consecutive years approached the village.

In Chapter 3, we understand the status of each bear that inhabited the Satochi using individual identification by hair-trapping method. The site, the operation period, and the number of units where hair trap was operated were exactly the same as those of camera trap of Chapter 2. We identified individual bears by microsatellite genotyping of bear DNA from hair collected with hair traps. As a result, we identified 41 bears (29 bears in 2012, 12 bears in 2013).

As in Chapter 2, we assumed that the population density of bears in autumn of 2013 was relatively low, based on the mean number of identified individuals, and the number of new individual bears in the latter term.

We classified individuals into resident bears and transit bears using the same definition as in Chapter 2. As a result, there were 4 resident bears and 37 transit bears in two years. Although there were no individuals identified for two consecutive years, we concluded that bears moved in and out of the study area, because 12 bears were identified in 2013, and the ratio of transit bears in each year accounted for more than 80% of the total. 2 resident bears of each year approached the village.

In Chapter 4, we comprehensively analyzed the status of each bear clarified in Chapter 2 and Chapter 3. There was a possibility of individual bears of camera traps and hair traps confirmed at the same sampling times and the same trap location could have the same individual. We examined combinations of individuals with the same individual potential. As a result, 12 pairs of bears could have the same bear in two years. If the individuals were consistent among the 12 pairs, the number of individual bears combined with both methods became 50 bears in the two years.

Among the above assumptions, there were 5 resident bears, 10% of the total number of bears (50 bears). We concluded that bears moved in and out of the study area frequently. Furthermore, from the above assumption, we concluded that 90% of individuals inhabited the study area are transit bears and only 10% of resident bears. Also, we considered that the population density of bears in autumn was affected by the hard mast production. However, we concluded that 3 bears of the above resident bears were strongly attached to the study area regardless of the hard mast production. In addition, we considered that two of them were bears dependent on the village, because the 2 bears have approached the village for two consecutive years. In this study, we decided that these 2 bears are urban bears.

As above, 90% of individuals inhabited the study area are transit bears, and we concluded that bears moved in and out of the study area frequently. Therefore, if bears that had been damaged so far were transit bears, even if they were able to kill the damaged bears, we presumed that the damage did not decrease since new bears were transferred one after another. Also, we considered that there was a high possibility that the 2 urban bears were damaged. However, these bears were not captured at least during the study period. Therefore, we considered that measures put emphasis on capturing only at the study area is not realistic, and a method of proceeding in a complex manner including other measures is effective in the study area.

In Chapter 5, we attempted to extract RAs where the danger of intrusion of bears is high, for the purpose of proposing effective measures in the Satochi. First, we analyze the relationships between Satochi environment that is quantified using a geographic information system and bear intrusion sites to extract RAs. The results showed that among the environmental factors we evaluated, forest surrounding, the forest edge with poor management, and land usage as an orchard were associated with bear intrusion. These results suggest that orchards with poorly managed forest edges along the forest boundary are more likely to be damaged by bears. On the basis of these results, we then extracted RAs classified as Low RAs (hereinafter, [LRAs]), Medium RAs (hereinafter, [MRAs]) and High RAs (hereinafter, [HRAs]) in increasing order of risk. As a result of superimposing the intrusion sites (70 sites) reported between 2004 and 2008 on each RA, there were 1 site (1.4%) in LRAs, 19 sites (27.1%) in MRAs and 33 sites (47.1%) in HRAs. We considered that damage control in HRAs is strongly needed to reduce the damage by bears, because the intrusion sites were concentrated in the RAs.

Furthermore, as a result of superimposing the intrusion sites (28 sites) reported between 2009 and 2010 on each RA, there were 3 sites (10.7%) in LRAs, 7 sites (25.0%) in MRAs and 10 sites (35.7%) in HRAs. The intrusion sites were concentrated in the RAs, and there was no significant difference between period from 2004 to 2008 and period from 2009 to 2010 in the ratio of the number of intrusion sites overlapping with RAs. Therefore, we concluded that RAs had a certain level of universality for bear intrusion.

Then, we attempt to extract RAs in Sayama area adjacent to Hocchi area. As a result, we were able to extract RAs, and the intrusion sites were concentrated in the RAs. As a result of superimposing the intrusion sites (76 sites) reported between 2004 and 2010 on each RA, there were 4 sites (5.3%) in LRAs, 14 sites (18.4%) in MRAs and 50 sites (65.8%) in HRAs. Therefore, we concluded that RAs had universality for bear intrusion in fruit growing regions.

Finally, by using the electric fence spread to the study area, we examined whether the protection of RAs in Hocchi area and Sayama area reduced the damage by bears. We defined the period between 2004 and 2008 as before measures, and the period between 2012 and 2013 as after measures. As a result of examining the installation situation of the electric fence after measures, the ratio of the area of RAs effectively protected by the electric fence to the total area of RAs was 70.7% a year on average in Hocchi area, and 41.2% a year on average in Sayama area. Comparing the number of intrusion sites before and after measures, the number of sites after countermeasures was 61% less in Hocchi area and 43% less in Sayama area. Also, the ratio of damage occurred in RAs within the analysis area was decreasing in Hocchi area. Therefore, by protecting approximately 71% of RAs with electric fence in Hocchi area, we concluded that the damage by bear along the forest edge decreased. However, there was no significant difference in the ratio of damage occurred in RAs within the analysis area before and after measures in Sayama area. Therefore, by protecting approximately 41% of RAs with electric fence in Sayama area, we concluded that the damage by bear along the forest edge decreased. However, the site where the damage by bears occurred remained concentrated along the forest edge. That reason was that orchards were concentrated along the forest edge. We consider that strengthening measures like installation of a long electric fence along the forest edge will be necessary. We were demonstrated that the protection of RAs with electric fence is effective in reducing the damage by bears. Therefore, we concluded that extraction of RAs and installation of electric fence are effective against bear damage.

We considered that at least 2 resident bears inhabited the study area for two consecutive years were urban bear. There was a high possibility that the 2 bears were involved in the damage, because these bears have approached the village. Furthermore, habitation in the Satochi of such individuals can be a great threat to the local population regardless of the number of individuals, from the viewpoint of living damage and spiritual damage of bears. Also, repeating the approach of these bears to the village means that there is a high possibility of encountering a human, and danger of human injury. This study is the first study to elucidate the actual conditions of urban bears. Then, this study suggest that measures put emphasis on capturing only at the study area is not realistic, and measures to control damage in the village are important for solving the bear damage problem. Also, we can demonstrate that it is possible to reduce bear damage by strategically proceeding measures, using extraction of RAs. We expect to be able to reduce the damage by bears in other areas by dealing strategically like the study area. We consider that the result of this study is knowledge that provides important information to strategically proceed measures against bear damage in the study area and other areas.