Issues in Student Surveys of Animal-damaged Trees in a Research Forest

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学生実習による演習林獣害調査の問題点

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要旨：学生実習による獣害調査を通じて，授業の問題点とその改善について検討した。信州大学農学部手良沢山演習林のコウヤマキ植林地において，参加学生 13 名を 3 班に分け，対象地の面積を概ね 3 等分して，獣害の観察と輪尺を用いた胸高直径（DBH）の計測を実施した。その結果，全体で 175 本の立木が調査され，うち 125 本が被害を受けていた。対象地全体では DBH の分布は正規分布であったが，班ごとに見るとサンプルサイズの影響で正規分布からやや外れており，平均 DBH の差が有意であった。被害木の内訳は班ごとで有意に異なっており，動物の行動の影響が考えられた。これらの対策として，面積比ではなく事前調査に基づいて対象地を分割することにより，均一な調査地を提供すべきと考えられた。また，輪尺を誤用したことによる計測値が多数を占め，同じ班でも異なる精度と計り方で計測している例も見られた。その対策として，学生間のコミュニケーションを高めるための働きかけや班編成が必要と考えられた。

キーワード：学生実習，森林調査，サンプルサイズ，輪尺

Key words: Practical training for students, Forest survey, Sample size, Caliper rule

Introduction

Instruction through fieldwork is expected to give the participating students an impression of how discoveries are made, an appreciation of working with colleagues, a sense of responsibility, and an awareness of what is required to be a participant (Kawaguchi, 2007). It is also important that fieldwork provides a plan for contributing to society within a short period, which will enhance the interest of students and make a positive impression on them (Onuma *et al*., 2007). It is important to provide such experiences to students in forest science, especially regarding damage to planted trees from animals: students are often interested in the ecology and behavior of wild animals, while they are often indifferent to animal-damaged trees.

In Terasawayama research forest at Shinshu

University, severe damage has been caused by animals in many young forests of planted *Chamaecyparis obtusa* and *Sciadopitys verticillata*, mainly by sika deer (*Cervus nippon*) and Japanese serow (*Capricornis crispus*). A case study in a juvenile *C. obtusa* forest revealed 2,296 (82%) animal-damaged seedlings among 2,801 existing trees, requiring around 1,900 supplementary seedlings to be replanted (Okamoto *et al.,* 2008). Because of the long-term growth of trees, it is not easy to judge whether to leave or give up damaged seedlings without the expert knowledge and experience of forest management engineers. Educators must also instruct in many areas of knowledge and techniques that are mainstays of forest management, e.g. tree planting, branch trimming, forest thinning, and forest road design. Consequently, problems related to animal-damaged trees have scarcely been addressed in forest science education at this university. These circumstances encourage the students to be indifferent to animal-damaged trees even in forests they have planted.

To improve education related to animal-damaged trees in forest management, a survey of trees in a research forest was conducted as practical training for students in 2016. Some of the issues identified that require improvement in this training program are discussed.

Method

The survey site was located in Terasawayama Research Forest at Shinshu University (Ina City, Nagano Prefecture, central Japan). *Sciadopitys verticillata* trees had been planted at this site at a density of 0.16 trees per m^2 in April 1983 over a total area of 1,200 m^2. The slope direction was NNE to NW, at an elevation of 1,000 to 1,030 m above sea level (Arase *et al.,* 2017).

Survey of animal-damaged trees was conducted as practical training for students as part of the program "Training for field science of agriculture and forestry" at the Faculty of Agriculture of Shinshu University on June 24, 2016. Thirteen students, almost all beginners at fieldwork, attended the survey. Five members of the education staff (two teachers, one engineer, and two senior students of teaching assistant) instructed the students attending.

After arriving at the survey site, the students observed animal-damaged trees and learned the purpose and significance of the survey. Then the students were randomly divided into three groups (groups A, B, and C) each comprised of four or five persons. The survey site was also divided into three zones of approximately equal areas. Each group was assigned to survey one zone.

Diameter at breast height (DBH) and the extent of animal damage (most was due to bark stripping at the survey site) of all existing trees were measured. For measuring DBH, a caliper rule for forestry with a 2-cm round scale was employed. This scale is used in the timber market in Japan, for which, e.g. '10 cm' means a diameter from 9 to 11 cm, and therefore zero is expressed as '1 cm' on this scale. The caliper rule has different scales back and front: one is a 2-cm round scale (with 5-mm divisions) and the other is an ordinary scale (with 2-mm divisions). The education staff told the students orally to read the 2-cm round scale.

After the survey, each group presented their rough results on tree growth and animal damage, and the students exchanged information and opinions. Then the education staff exhibited criteria for tree selection for forest thinning, and each group returned to their assigned zone and selected trees for thinning.

Results

At the survey site, 175 trees were measured. Group A, B and C respectively measured 71, 47, and 57 trees in their assigned zones (Table 1). Significant differences were detected in average DBH among

Table 1 Number of trees and their DBH at the survey site

Items		Group A	Group B	Group C	Total
Number of trees		71	47	57	175
DBH (cm)	average	11.0 b	13.4 a	11.3 b	11.7
	± SD	3.3	3.5	3.7	3.6

Different letters denote significantly different averages as determined by Tukey's HSD test (p <0.05).

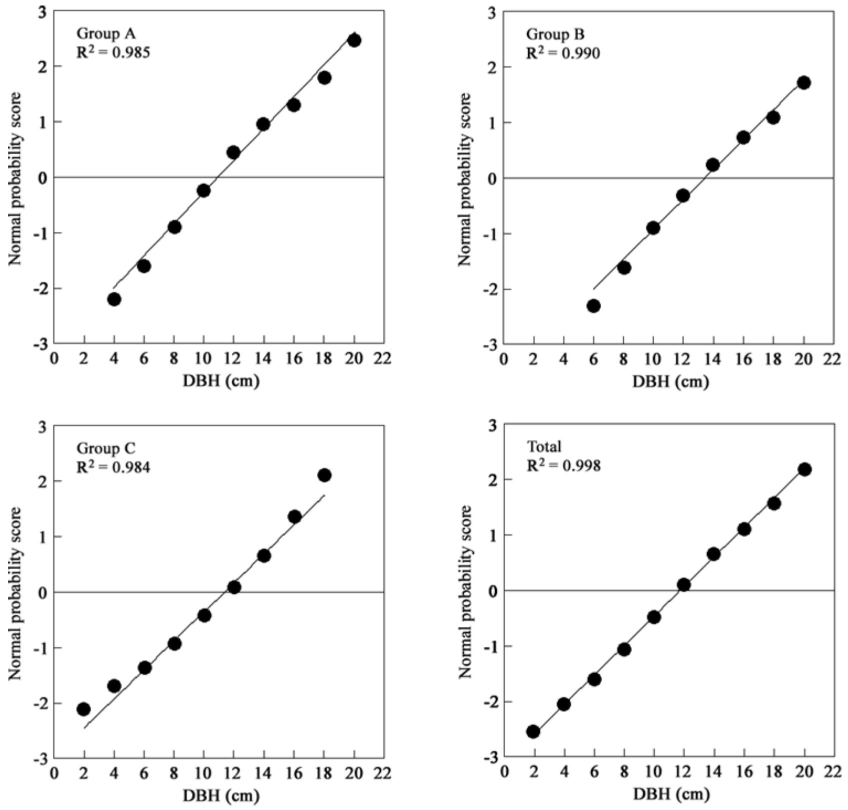

Fig. 1 Normal Q-Q plots for DBH data

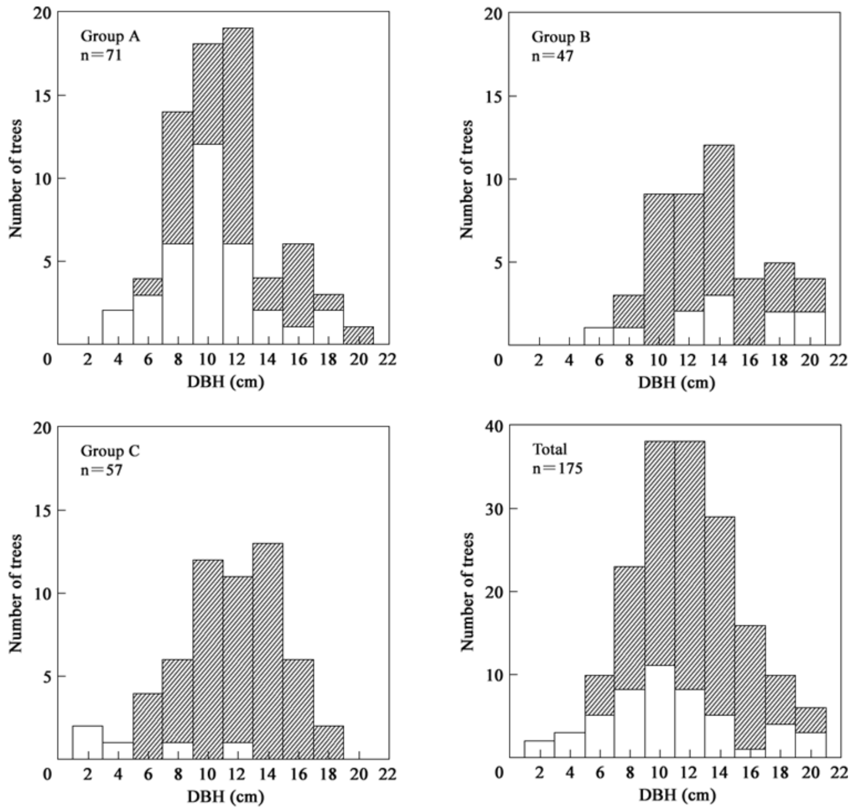

Fig. 2 Histograms of DBH measured in the practical training for students. Shaded portions indicate animal-damaged trees and unshaded portions indicate intact trees.

groups: Average DBH in group B (13.4±3.5 cm) was significantly larger (Tukey's HSD, p<0.05) than in group A (11.0±3.3 cm) and group C (11.3±3.7 cm). Therefore, although the survey area was divided approximately equally into three zones, both the number and size of trees were not uniform among groups.

To examine the distribution of DBH measured in each group, normal probability Q-Q plots (in which the plots are arrayed in a line if they fit a normal distribution) are shown in Fig. 1. In each of the three groups, the plots were arrayed roughly in a straight line (R^2=0.984 to 0.990), though the group B plot deviated a little at the left end (i.e. smaller DBH), and the group C plot deviated at both ends (i.e. smaller and larger DBH). The plots were closely arrayed in a straight line (R^2 =0.998) overall, meaning that the sizes of trees overall at the survey site followed a normal distribution, and roughly followed a normal distribution in all three individual zones.

Fig. 2 shows histograms of DBH values. As shown in Fig. 1, the data overall followed a nearly symmetrical bell-shaped histogram, suggesting a normal distribution. However, in groups A, B, and C, the histograms seemed rather irregular and asymmetric, consistent with the differing tree sizes among groups (Table 1) and the deviation from a normal distribution (Fig. 1).

Bark stripping of animal-damaged trees was observed with an average length of 135.1 ±56.1 cm (average±SD, n=125). Animal damage occurred in each DBH class greater than 6 cm, and the proportion of damaged trees did not seem uniform among groups (Fig. 2); almost all trees were damaged in group C, while relatively few were damaged in group A. Table 2 shows the number of intact and animal-damaged trees. Significant differences were detected in proportions among groups (χ^2-test, p<0.00001), which means that the students did not have uniform subjects to survey.

Table 2 Number of intact and animal-damaged trees at the survey site

Items	Group A	Group B	Group C	Total
Intact trees	34	11	5	50
Animal-damaged trees	37	36	52	125
Total	71	47	57	175

In measuring DBH, there was unexpected trouble. Although at the beginning of the survey, the students had been told to measure DBH using the 2-cm rounded scale, they measured it in their own way. The education staff suspected this after the survey based on checking the data list, which included both integers and decimals. Therefore, the staff had to ask the students how they had read the scale of the caliper rule so they could adjust the DBH data to the 2-cm rounded scale.

Table 3 shows that the use of three scales in the data measured by the students. Data were correctly measured only in group A. 'Too accurate' data, read on the ordinary scale in 0.2-mm segments, was measured in groups A and C, which was easily transformed to the 2-cm rounded scale. 'Mistaken' data were measured in group B, which was most troublesome: the data required correction by first subtracting 1 cm, then rounding the values to the 2-cm rounded scale (e.g. '11.5 cm' acquired in this way was equivalent to '10.5 cm' on the ordinary scale, which would correspond to '10 cm' on the 2-cm rounded scale). Correct measurements were as few as 25%. In group A, both correct measurements (62%) and too-accurate measurements (38%) were made. In both groups B and C, only one scale was employed throughout the survey, but not according to

Table 3 Number of trees measured correctly and in unexpected ways

Scale	Group A	Group B	Group C	Total
Correct	44	-	-	44
(reading the 2-cm rounded scale)	(62%)			(25%)
Too accurate	27	-	57	84
(reading ordinary scale in 0.2-mm segments)	(38%)		(100%)	(48%)
Mistaken	-	47	-	47
(estimating mm-order DBH by eye on the 2-cm rounded scale)		(100%)		(27%)
Total	71	47	57	175

how students were instructed to use it.

Discussion

Although educational materials should be prepared uniformly for students (Tanaka and Kawasumi, 1994), the survey site of the present study was not shared equally. This suggests that division of the survey site merely on the basis of area was not sufficient for instructing students on performing the field survey. Survey by educational staff before the training would facilitate the determination of how to divide and assign the site.

In the zones divided into the three groups, the number of existing trees was uneven, and the average DBH significantly differed (Table 1). The range in DBH followed a normal distribution closely overall, but only roughly in the divided zones (Figs. 1 and 2). Statistically, the confidence intervals of population data in a national census are designed to fall within an allowable range, but a subpopulation data in each region (i.e. divided data from the national census) is not reliable because of excessive sampling error caused by small sample size (Matsui, 2008). The deviation from the normal distribution in this study is also suggested to have been caused by dividing the sites into small zones: if there were more students, the site would be divided into smaller zones with a smaller number of trees to allot to more groups, and the difference in DBH among groups and the deviation from the normal distribution would be larger.

Furthermore, the proportion of animal-damaged trees significantly differed among zones (Fig. 2 and Table 2). This finding could not be explained in the present study. It is presumably related to animal behavior, since animal damage to trees reportedly is influenced by the distance from roads or rivers, location on slopes, and the distribution of target plant species (e.g. Okamoto *et al.*, 2008). These specific influences on animal behavior will induce uneven distribution of animal-damaged trees, which is difficult to control or estimate before survey.

The unexpected trouble in measuring DBH (Table 3) was related to two problems, insufficient instruction and lack of communication. Insufficient instruction on how to measure DBH was caused by the one-sided assumption of education staff that the students had already learned the basic knowledge and skills of forest science. The error in using the rounded scale in the forest survey was reportedly accidental and was sufficiently small to be less important than systematic errors due to mistaken measurements and instrument error (Sugahara, 1963). Precision of data and the correct way to measure should be specified clearly in any handouts about the survey procedure.

Lack of communication might be a problem of personality or morale in students. In group A, in particular, the data list contained both integers and decimals, because two different scales (the 2-cm rounded scale and the ordinary scale in 2-mm segments) were employed. The data list seemed odd. The students could easily have noticed the difference as soon as the measured value appeared more accurate or rough, but they disregarded the discrepancy. Although some members of the group might have noticed a change, this information was not shared or discussed in the group.

The composition of members of groups is reported to influence the results of co-operative work, which tends to be more active and rapid when members are determined by consensus than by lottery (Matsumoto et al., 2008). Since the division of students was not by consensus among students, the arbitrary composition of members might have lowered communication or morale during the survey. An attempt by education staff to encourage communication within each group, or to divide the students into groups with the consensus of the students may be needed.

Conclusions

To improve education on forest management of animal-damaged trees, a survey of the trees in a research forest was conducted as practical student training. The students were divided into three groups of four or five, and the survey site was also divided into three zones of approximately equal area. Each group was assigned a survey of existing trees in a single zone. Some issues of this training program were discussed, including:

1. The issue of small sample size: division of the survey site into small zones for each group is considered to have resulted in differences in average DBH measurements among zones, and some apparent deviation from a normal distribution.
2. The issue of uncontrollable unevenness: the proportion of animal-damaged trees differed among zones, perhaps due to differences in animal behavior. This unevenness is hard to control and estimate.
3. The issue of communication: unexpected trouble in measuring DBH occurred and most of the data were measured incorrectly by caliper rule. This was caused by lack of communication among students as well as by insufficient instruction by educational staff.
4. The supply of uniform materials for education on forest fieldwork, especially related to animal damage, requires a prior survey by educational staff.
5. For improvement of communication among students, educational staff needs to encourage communication within smaller groups, or to divide the students into such groups with their consensus.

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