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고사목에 서식하는 절지동물군집의 기능군별 분류: 윈도우 트랩과 우화 트랩의 비교

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Classifying Arthropod Communities in Dead Wood with Functional Groups: Comparing Window and Emergence Traps

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ABSTRACT

This log-dwelling arthropod community study was conducted for the ecological evaluation of dead woods at Korean fir stand in Mt. Woonak which located in Pocheon-si (city) from April 2010 to August 2012 (except for the period from september 2010 to April 2011). We collected 3,484 individuals (5 classes, 18 orders, 52 families) by using the passive method, but we didn't include the number of unidentified larva for this study. For the window traps, we collected 2,184 individuals (3 classes, 18 orders, 51 families). We classified those individuals from window traps into the five functional groups and we discovered the proportion and richness of each functional group : herbivores (29.2%, 14) saproxylophagous (25.0%, 12), xylophagous (12.5%, 6), predators (27.1%, 13), detritivores (6.3%, 3). For the emergence traps, we collected 1,730 individuals (3 classes, 18 orders, 36 families). We classified those individuals from emergence traps into the five functional groups and we discovered the proportion and richness of each functional group : herbivores (31.4%, 11), saproxylophagous (22.9%, 8), xylophagous (17.1%, 6), predators (25.7%, 9), detritivores (2.9%, 1). Overall, we suggest that window traps are more efficient to catch herbivores group (especially, Coleoptera and Hymenoptera) and emergence traps are good at catching the predator group(particularly, Ant and Araneae). We concluded that each passive trap has different efficiency according to the arthropod characteristics. Rather than using just one trap, if we use the trap with adequate purpose, we can enhance the efficiency of catching. This study found a relationship between the dead woods which related to a biodiversity loss and the community of arthropods which make up more than 76 percent of biodiversity. Our study can help in finding the role of dead woods in the forest ecosystem as habitat. When preparing the proper forest managements considering this fact, the forest will be more complex. Also, it can improve the structure and function of the forest ecosystem.

Key words : dead wood, arthropod, functional group, the passive method

Introduction

Biodiversity is the combination of life forms and their interactions with each other and with the rest of the environment. The loss of biodiversity destabilizes ecosystems, and weakens their ability to deal with natural disasters. Specifically, mutual dependence of ecosystems will decrease. Hall (2010) pointed out that biodiversity is continuously declining at genetic, species and ecosystem levels, and the ecological footprint by humans is overwhelming the biological capacity of the earth. One of the current issues in the forest is the impact on forest resource management and the conservation of biodiversity in the forest of the future. Forest deterioration and habitat destruction, has resulted in the loss of biodiversity, and has received growing concern throughout the world since the 1980s (May, 1988). Biodiversity in the forest results from evolutionary processes over thousands and even millions of years. Within specific forest ecosystems, the maintenance of ecological processes is dependent upon the maintenance of their biodiversity (Yoon, 2002). In production forestry terms, dead woods are often regarded as “waste” implying it ought to be put to better use. However, dead woods have many ecological functions in natural forest ecosystems, some of which have been reviewed (Grove *et al.*, 2002). (1) Nutrient cycling (Olson, 1963), (2) Carbon storage (Jenisch and Harmon, 2002), (3) Soil conditioner (Smith *et al*., 2001), (4) Moisture reservoir and refuge from environmental extremes (Amaranthus *et al*., 1989), (5) Provision of physical habitat structure (Butts and McComb, 2000), (6) Nesting/denning sites(Duncan and Taylor, 2001), (7) Substrate for saproxylic and epixylic organisms (Speight, 1989). Dead woods provide habitat for several species of small mammals and amphibians. As a result, the decline of dead woods causes a decrease in wood dwelling species and biodiversity in forest ecosystems decreased. Especially, the decreasing in number of endangered species which uses dead woods as a habitat or spot for winter are affected by the damage of dead woods caused by artificial forest management. Arthropods have an influence on dead woods in the forest (Wilson *et al*., 1999). Living on dead wood requires the dependence of a dynamic and transient substrate. This implies that populations must be able to compensate local extinctions on individual logs and within forest stands with repeated colonization to ensure survival at the landscape level. Understanding these colonization-extinction dynamics is essential for successful biodiversity management. Numerous studies have shown the key importance of dead woods for biodiversity in boreal forests. The large number of species related to dead woods (Siitonen, 2001) is one reason behind a growing interest in incorporating woody debris into forest management planning for multiple-use forestry. Korean forests are mainly composed of conifer species plantations rather than natural forests. Pine trees of conifers are damaged by insects and pine wilt disease every year. Present forest management programs are put into place when there are many dying pine trees. The trees are immediately cleared in the forest. This is not only for conifers, but for almost all tree species depending on forest management in a Korean forest. Recently, a number of Korean research of dead wood is smaller than abroad, and the research points are narrow. Research has been under way for years to confirm the hypothesis that dead woods provide habitat, rich nutrients and a variety of insects for animals in the forest. But, experimental design studies have not had contentable results for testing the hypothesis. As a result, an relevant study of dead woods that have a significant role in the forest ecosystem is needed at all costs. This study can help in finding the role of dead woods in the forest ecosystem. Furthermore, the research for finding what kind of species exists in dead woods is based on purpose. This study sets up the hypothesis: "In dead woods, many species of arthropods exist."Additionally, passive traps (Window trap and Emergence trap) have different efficiency according to the arthropod characteristics.

Materials and Methods

1. Study area

The study was conducted in one area; study site was located on Mt. Woonak (37°45'40.84"N, 127°10'21.03"E) nearby Gwangneung in central Korea. This mountain's height is 234.8m (Fig. 1). This area was registered as an experimental forest in 1939. Since then, it began artificial forestation with *Pinus koraiensis*, *Larix leptolepis*, *Larixol gensis* var. *koreana*, *Pinus rigida*, *P. banksiana*, and other conifers. This study site consist of simple species. Dominant species were oaks and Korean firs in each area.

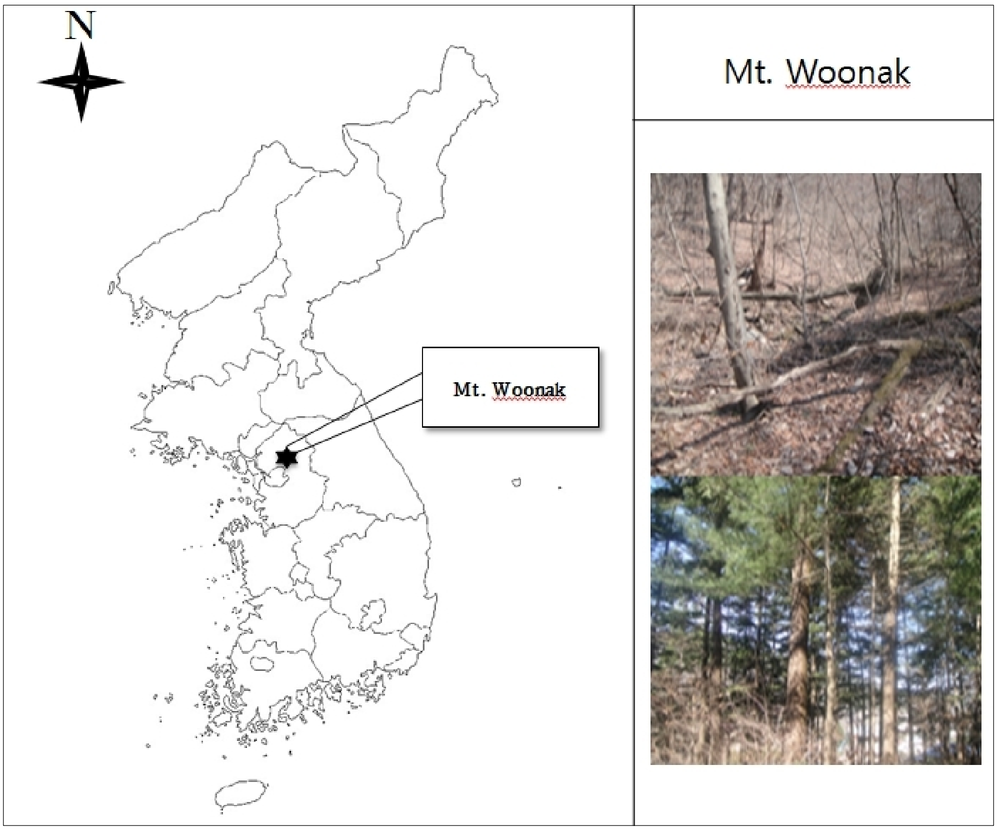

Fig. 1. Showing the study site : Mt. Woonak is located nearby Gwangneung in central Korea.

2. Sampling methods

1) Two passive methods (Window trap and Emergence trap)

The full design consisted of two passive traps and four Korean fir standing dead woods (snag) in the experimental unit on Mt. Woonak (conifer forest). The passive traps that were used were a window trap (Fig. 2; A, C) and an emergence trap (Fig. 2; B, D). The window trap had two transparent rigid plastic sheets, Φ 20cm funnel and plastic container. 20 by 30cm sheets and perpendicularly placed sticks were used in the window traps. They were placed perpendicular to each snag at the level of 1.5m～2m from the ground as a flight intercept at the site. A plastic sample bottle, with a total volume of 250ml, was half-filled with attenuated ethylene glycol, and was attached under the plastic to collect the insects. They were attached to the south. The containers were attached as close as possible to the trunks.

The emergence trap enclosed a 1m by 2m wide strip around the snag, and was positioned in the snag at the level of 1.0m～1.5m from the ground. A black plastic fabric polypropylene barrier was used to enclose the tree. Along the borders of the trap, staples and a steel wire secured the fabric to a wide strip where the bark achieved a close fit from the cloth. A hole was made in the cloth to which a lid for the transparent plastic container, with a total volume of 250ml, half-filled with attenuated ethylene glycol, was fastened. This was the only place where light came into the trap. Arthropods emerging from the trap were caught in the bottle screwed into this lid. The plastic containers of the traps had a sampling period each month.

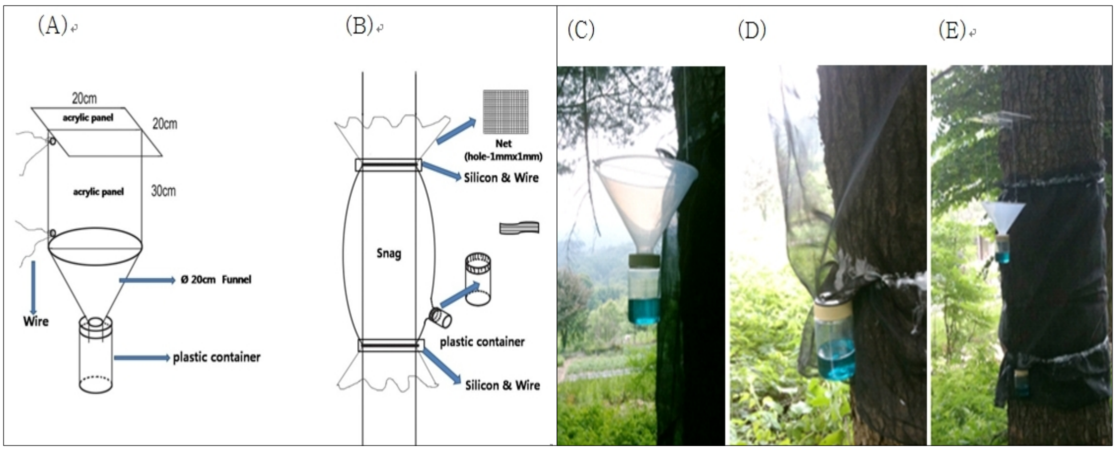

Fig. 2. The photos of setting the passive methods. Window trap of flight interception type mounted on the dead wood of snag (A, C), two transparent rigid plastic sheets, 20 by 20cm and 20 by 30cm, with funnel and a plastic container half-filled with ethylene glycol. Emergence trap (B, D), a black plastic fabric polypropylene weed barrier secured by staples and wire enclosing a 1.0m wide strip around each snag, an internal support of plastic cap held the cloth away from the wood to allow the arthropods to move. Two different traps were set up at the same Korean fir dead woods (E).

2) Identification

Each arthropod in the wood samples was identified to species by its morphological characteristics, but a few larvae were not included if they could only be determined to order or family. And some unidentified species were shown as family sp. forms. Species were also classified concerning their functional association as herbivores, fungivores, xylophagous, saproxylophagous, detritivores, and predators (Bouget *et al.*, 2005). The definition of each group was as follows: herbivores ate plants, leaves, stems, etc. Xylophagous ate dying or newly dead wood. This included ambrosia eaters. Saproxylophagous ate decayed wood. Detritivores ate dead insects, frass, etc. Predators ate insects.

3) Statistical analyses

The Shannon-Weiner diversity index was calculated, with evenness included, as well as the Simpson diversity index (McCune and Mefford, 1999; McCune and Grace, 2002). ANOVA was used to test the differences in mean abundance, mean species richness, and mean species diversity for the arthropod community in downed dead woods (SAS Institute, 2001). The F-statistics were calculated for site, decay stage, tree species, and their interactions. The Duncan procedure was used to compare treatment means. In all the analyses, the level of significance was at least P=0.05 (SAS Institute, 2001). Ordination analyses with the pooled data were done by using PC-ORD version 4.28.

Results

1. Overall arthropod community of abundance and species composition

The four Korean fir standing dead woods, arthropods consisted of 3484 individuals (5 classes, 21 orders, 52 families), but the number did not include the larva. The total number of arthropods in all the passive traps consisted of five functional groups: herbivores (11.5%, 399), xylophagous (59.3%, 2065), saproxylophagous (6.5%, 227), detritivores (7.5%, 260), predators (15.3%, 533). The total number of arthropods species richness also consisted of five functional groups as seen below (Fig. 3): herbivores (26.9%, 14), xylophagous (13.5%, 7), saproxylophagous (25.0%, 13), detritivores (5.8%, 3), predators (28.8%, 15). The indices of arthropods in the passive traps are shown in Table 1. Species richness was higher in the window traps than in the emergence traps. And Shannon's diversity and evenness index were also higher in window traps than in the emergence traps. Contrary to this, the dominant index was higher in the emergence traps than in the window traps.

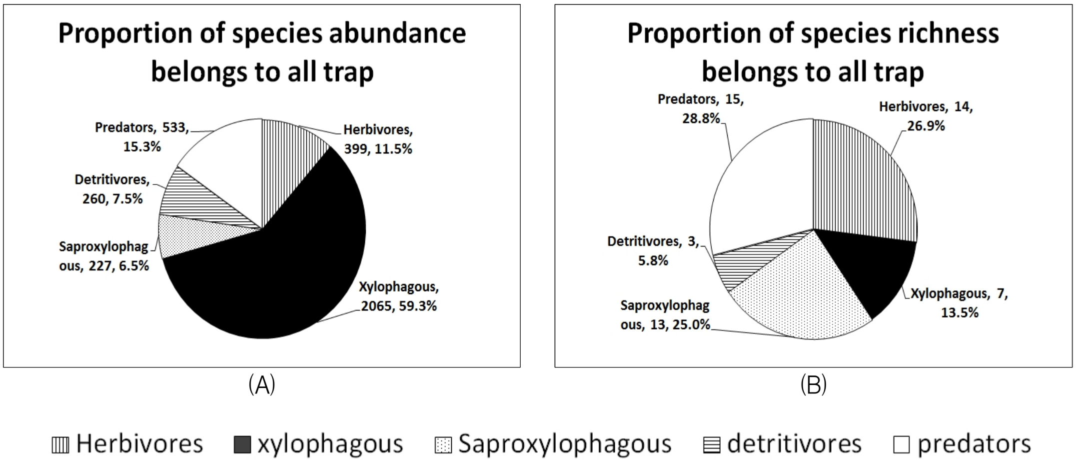

Fig. 3. Proportion of species abundance (A) and richness (B) belonging to all passive methods.

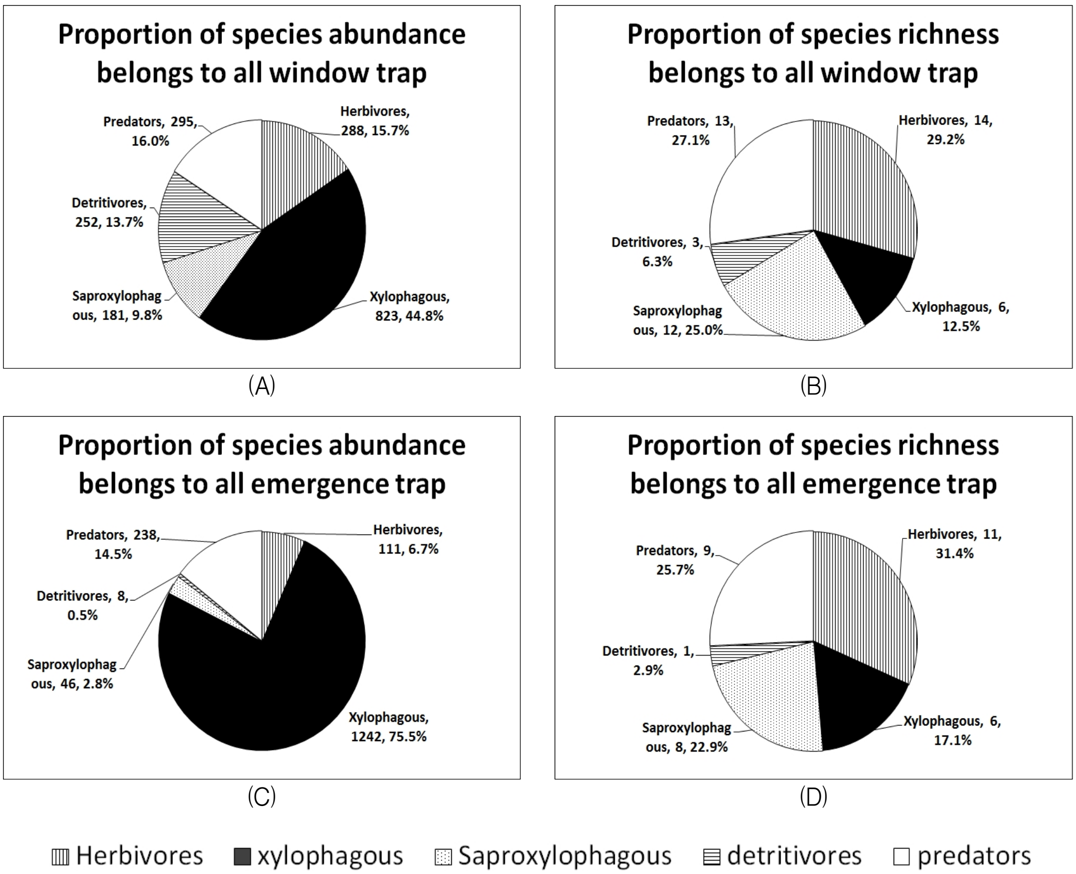

Fig. 4. Proportion of species abundance (A) and richness (B) belonging to all window traps and proportion of species abundance (C) and richness (D) belonging to all the emergence traps.

Table 1. Indices of arthropod community in passive methods

	S	E	H	D'
Window trap	48	0.69	2.673	0.88
Emergence trap	35	0.39	1.38	0.50

S of indices is species richness index, E of indices is the evenness index, H of indices is Shannon's diversity index, D of indices is Simpson's diversity index.

2. Efficiency of each trap

To compare the window traps and emergence traps, We used ANOVA (N=12) with the post hoc Duncan test (pair wise test, N=12). As a result, the mean number of species richness were significantly different for the two trap methods. The herbivore groups were higher in the window than in the emergence traps. Also, the dominant index (D) of the window trap was higher than in the emergence traps (Table 1). Another difference was with the arthropod characteristics. The window trap caught flying arthropods like flies and bees. In comparison, the emergence trap caught crawling arthropods like springtails, ants. The emergence trap sampling caught more xylophagous individuals than the window traps. In our study, the emergence traps and window traps caught a different number of arthropods in the five functional groups. Compared to the emergence traps, Ola *et al*. (2007) also found that window traps caught more individual arthropods and more species. This same result happened in our study. Window traps are more efficient to catch herbivores group (especially, Coleoptera and Hymenoptera) and emergence traps are good at catching the predator group (particularly, Ant and Araneae) (Fig. 4). An analysis of the arthropod communities using 56 traps samples (two traps X four trees X seven months), using non-metric multidimensional scaling (NMS) with 11 variables, showed that the arthropod community structure responds through the dominant index content. The dominant index is correlated to Axis 3. The other variables also had correlations. Axis 1 explains the 19.8% variance and Axis 3 explains the 51.3% variance. In total, the 71.1% variance was explained on the NMS plot with 120° rotation. The plot shows the distinct point clouds among traps (window trap, emergence trap) (Fig. 5). The method of catching the most of individuals and/or species richness is considered to be the most efficient. The results from our study showed the efficient trap that different traps had different arthropod assemblages. The passive methods take a long time to study, these are non-destructive and suitable for long-term studies in which the same dead wood object must be sampled over time or in situations where the researcher must avoid any destruction of the dead wood. Also, one of the passive traps, window trap, can catch the arthropods that influence the surrounding woods and environment by chance. The emergence trap has a reduction on these influences.

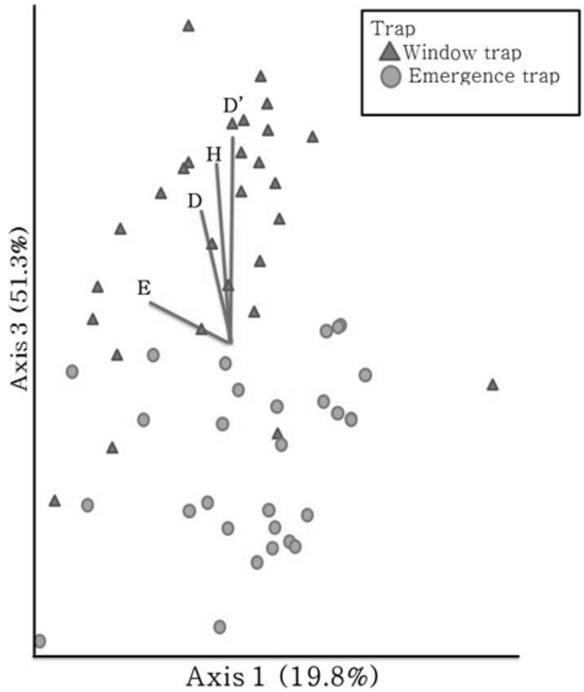

Fig. 5. NMS ordination of the arthropod communities according to traps (window and emergence trap) in Korean fir standing dead woods. The closed triangles (▲) are the window traps, the closed circle (●) are the emergence traps.

Table 2. Effect of trap, month and their interactions on the variable of the arthropods in the snag

Variable	Trap (T) df=1	Month (M) df=5
No. of abundance	0.5006	0.2689
No. of species	0.0005*	0.0002*
Indices		
S	0.0005*	0.0002*
E	0.0811	0.0097*
H	0.0010*	0.0032*
D	0.0029*	0.0117*
Functional group		
Herbivores	0.0064*	0.0003*
Xylophagous	0.0003*	0.0353*
Saproxylophagous	0.0015*	0.0483*
Detritivores	<.0001	0.5425
Predators	0.3173	<.0001

S of indices is species richness index, E of indices is the evenness index H of indices is Shannon's diversity index, D of indices is Simpson's diversity index.

*=p<0.05; **=p<0.001

Conclusion

In our study, We compared the effectiveness of two traps (window trap and emergence tra). Window trap and Emergence trap are very useful to catching arthropods in dead wood (Ola *et al*., 2007). But, there are different efficiency between two traps. Window trap is more efficiency, when catch the herbivore group. and Emergence trap is more efficiency, when catch the crawling arthropods and predator group. That result is similar to Lee *et al.* (2012) result. The logs play an important role for arthropods as habitats. They are also an excellent source of nutrients. Managed forests occupy 99% of the total productive forested area in Korea. Forest management removed and/or fumigated dead woods. Dead woods must be retained and/or created in forest management such that this substrate is continuously available in the future. This forest management will likely contribute significantly to the biodiversity value of managed habitats and the conservation of endangered species. We are lacking in dead woods research compared to other countries. Studies have lacked basic necessities for all arthropods and functional groups of arthropods in dwelling dead wood. Long-term monitoring of dead woods will allow us to obtain reliable information on how dead wood dwelling arthropods benefit from conservation-oriented treatments over the lifetime of a dead wood object based on our study. Overall, when the dead wood is sustained in the forest, the arthropod community will be more complex in various aspects. Thus, we realized that the dead woods are important as a component factor in the forest. When we come up with forest management measures with these important facts, so that dead wood has a good role in the forest, the arthropod community, the species biodiversity of arthropods and predator biodiversity will be more complex and maintainable.

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요 약

고사목에 서식하는 절지동물군집의 구조를 연구하기 위해 2010년 4월부터 2011년 10월까지 포천시 광릉 운악산에서 조사를 진행하였다(2010.09.28∼2011.04.21. 제외).

절지동물군집은 각 지역별로 누워있는 고사목에서 수동적 채집 방법(Passive method)을 사용하여 채집되었으며, 종 수준으로 분류 후 다시 섭식 기능군을 기준으로 herbivore, xylophagous, saproxylophagous, detritivore, predator로 분류하였다. 수동적 채집 방법에서의 결과는 전체 트랩에서 5강 21목 52과 3,484개체가 채집되었다. 윈도우 트랩(Window trap)에 채집된 절지동물은 3강 18목 51과 2,184개체로 herbivores (29.2%, 14) saproxylophagous(25.0%, 12), xylophagous(12.5%, 6), predators(27.1%, 13), detritivores (6.3%, 3)로 나타났으며, 우화 트랩(Emergence trap)에 채집된 절지동물은 3강 18목 36과 1,730개체로 herbivores(31.4%, 11), saproxylophagous(22.9%, 8), xylophagous(17.1%, 6), predators(25.7%, 9), detritivores

(2.9%, 1)로 나타났다. 두 트랩의 비교 결과, 윈도우 트랩은 herbivore 기능군을 채집할 때 효율성이 높았고, 우화 트랩은 predator 기능군을 채집하는 데에 효율성이 상대적으로 높았다. 결론적으로 고사목에 서식하는 절지동물 군집의 채집에 있어서 하나의 단일 트랩을 이용하기 보다는 잡고자 하는 기능군의 특성에 맞는 트랩을 사용하면 채집의 효율성이 더욱 높아질 것이다. 고사목에 서식하는 절지동물 군집의 생물다양성 연구의 결과를 통해 산림 내에서의 고사목의 중요성을 인식하고, 산림관리 방안을 마련할 때 이 점을 반영하여 숲의 중요한 구성요소로써 고사목이 제 역할을 하게 된다면 절지동물의 종 다양성뿐만 아니라, 절지동물과 관계하여 살아가는 상위 포식자인 육상 동물들의 생물다양성이 더 복잡해지고 잘 유지될 것이다. 생물학적으로 다양한 숲에서의 이러한 복잡성이 생태계 내에서의 개체들이 기능을 유지할 수 있게 만들 것이다.

검색어 : 고사목, 절지동물, 섭식기능군, 채집방법