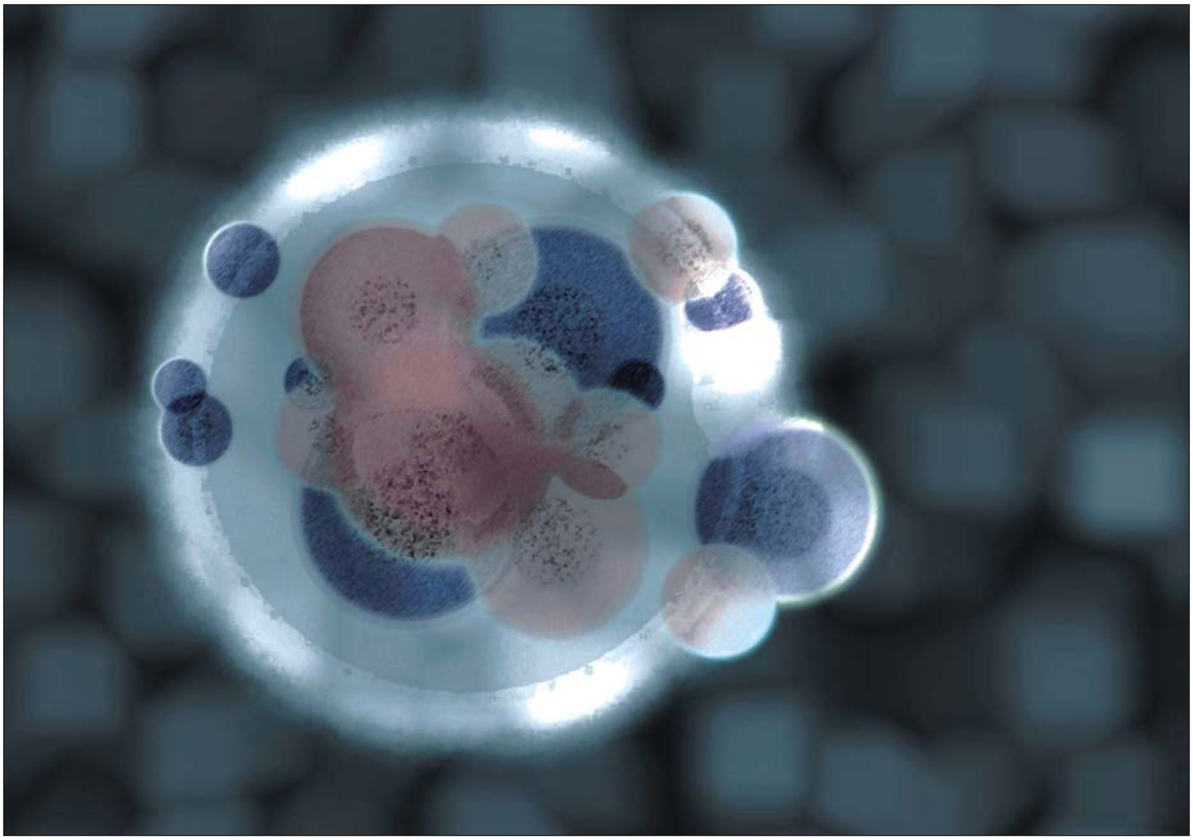

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Harmful Insects and Relationships Between Certain Tree Properties in Scots Pine (*Pinus sylvestris* L.) of Ilgaz Mountain, Cankiri, Turkey

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Abstract: In this study, five sample plots were selected from pure Scots pine (*Pinus sylvestris* L.) stands and DBH, height and crown diameter were measured on the live Scots pine trees, of which DBH was higher than 4 cm, in these sample plots in Ilgaz Mountain, Cankiri, Turkey. According to inspections on bark samples which obtained from Scots pines in sample plots and catches at the light trap, *Ips acuminatus* (Gyll.), *Orthotomicus erosus* (Woll.), *Pityogenes quadridens* (Hartig) (Coleoptera: Scolytidae), *Dendrolimus pini* (L.) (Lepidoptera: Lasiocampidae) and *Sphinx pinastri* (L.) (Lepidoptera: Sphingidae) were determined at stands of 15-45 cm dbh, 50-110 age, 30-50% slope, generally southeast and southwest aspects and at elevation of 1420-2080 m where Scots pine dominated. Regression analysis showed that there were statistically significant ($p<0.001$) and strong ($R^2>0.50$) relationships between DBH, tree height and crown diameter variables in Scots pines. The strongest relationship determined was the crown diameter-tree height relationship ($R^2 = 0.977$), followed by the tree height-DBH ($R^2 = 0.893$) and crown diameter-DBH ($R^2 = 0.874$) relationships, respectively.

Key words: Harmful insects, crown diameter, DBH, Tree height, *Pinus sylvestris* L., regression analysis

INTRODUCTION

Turkey is between Asia and Europe continents and surrounded by seas at three sides and also has a rich biological diversity due to her climatic, soil and topographic structure. Ilgaz Mountain where this study carried out is one of the rare natural and essential to protect forests, both nationally and internationally, due to its interesting geographic-geomorphologic structure, richness in unique plant societies, insect species and diversity.

Scots pine (*Pinus sylvestris* L.)'s distribution extent to 757.426 ha as pure stands in Turkey. This species distributes from Sinop (Ayancik) at north to Kayseri (Pinarbasi) at south and from Kars (Kagizman) at east to Bursa (Orhaneli) at west. The southest distribution point of Scots pine except Kayseri-Pinarbasi, is Afyon-Ihsaniye. Scots pine exists at elevations between 1000-2500 m, but also exists at sea level at Surmene-Camburnu in Eastern Black Sea region. The highest distribution elevation of Scots pine is 3125 m at Allahuekber Mountain in Turkey (Genc, 2004).

Scots pine in this study is the dominant species which is located on south aspects of Ilgaz Mountain at 1420-2080 m elevations and at High Mountain Forest level as compared to Alps in regards to forest and plant geography. Silvicultural practices of this tree species and control of harmful insects have a great importance in Ilgaz forest ecosystem. Previous studies suggested that damage of bark beetles is highly related to certain properties (i.e., dbh, crown diameter, age, tree count per ha, elevation) of trees (Witrylak, 1995; Capecki, 1982; Struble and Johnson, 1955; Massey and Parker, 1981; Christiansen and Bakke, 1988; Tsankov, 1989; Martin and Cobos, 1986; Simsek, 2003; Simsek and Oner, 2003). Thus, DBH, tree height and crown diameter parameters have a great importance in regard to both in silvicultural practices and control of insect pests. However, determination of parameters mentioned in lesser time and labor, needs certain modeling studies.

There is a close relationship between tree parameters such as diameter, height, crown size and bole volume (Philip, 1994). Using these allometric relationships, a dimension of which measurement is difficult can be estimated by means of other dimensions which can easily be measured (Kalipsiz, 1984). As a matter of fact, using the height-DBH relationship, heights can be estimated by means of DBHs (Saracoglu, 1988; Caliskan, 1991). Thus, the studies of forest inventory and stand structure determination can be made easier and at less cost.

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In this study, harmful insects and the relationships between individual tree DBH, height and crown diameter were investigated in Scots pine in the forests of Ilgaz Mountain, Cankiri, in 2000-2005. Thus, the possibilities of determination of height and crown diameter variables by means of regression equations for easier study and at less cost in the studies of ground-based forest inventory and stand structure determination to be made in the pure Scots pine stands of the research area were evaluated.

MATERIALS AND METHODS

This study was carried out in order to determine the relationships among dbh, height and crown diameter of Scots pine and damage of harmful insects in Scots pine stands. The main materials of the study were Scots pines and insects. Other material were tape, calipers, height meter (Blume-leis), increment borer, GPS, clinometer, stereo-microscope, Pennsylvania type light trap, thermal jug and 1/25000 scaled stand types map.

The data used in the study were measured from the natural pure Scots pine stands at elevations between 1420-2080 m of south aspects of Ilgaz Mountain that is located in the Ilgaz district of the Cankiri province. Transition climate zone from Central Anatolian steppe to Black Sea climate is seen at mid and upper elevations of the mountain.

Bark samples of Scots pines at various ages and dbh and insects collected from light trap were brought to laboratory in thermal jug and investigated under stereo-microscope and then determined insects were identified. Soil samples which represent study area were brought to laboratory and both physically and chemically analyzed.

Five sample plots were selected from the pure Scots pine stands, which had a normal structure, in the direction perpendicular to the contour lines. The sample plots were at 10×50 m dimensions. There were only Scots pines in the sample plots 1, 2, 3 and 4; but also 3 Uludag firs *(Abies nordmanniana* subsp. *bornmulleriana* Mattf.) in addition to Scots pines in the sample plot 5. Some site characteristics of the sample plots are given in Table 1.

DBH, height and crown diameter of the live Scots pine trees, of which DBH was higher than 4 cm, in the sample plots were measured; DBH, height and crown diameter were determined to the nearest 1 cm, 0.25 and 0.1 m, respectively. DBH was calculated as the arithmetic average of the two measurements that were made in the direction perpendicular to each other by a caliper, tree height was measured by a height meter. Crown diameter was calculated by measuring and adding the radii of the crown projection areas in four directions and then by dividing into 2 the value obtained. In addition, by taking the mean of the ages of the 3 dominant trees in the stand over story, the mean ages of the sample plots were found to be 62, 76, 80, 91 and 113, respectively.

Table 1: Some site characteristics of the sample plots

Sample plot No.	Location	Elevation (m)	Aspect	Slope (°)	Relief
1	Sekibasi	1430	Southeast	6	Middle slope
2	Kadincayiri	1570	Southwest	31	Middle slope
3	Besaraz	1640	Northwest	22	Upper slope
4	Karincalik	1820	West	21	Upper slope
5	Tasliksirti	2070	Southwest	30	Upper slope

The regression analysis was applied to determine whether there was a statistical relationship between DBH, height and crown diameter in Scots pine (Kalipsiz, 1981). The data of a total of N = 250 trees measured in all sample plots were included in the analysis; thus, the relationships between individual tree height-DBH, crown diameter-DBH and crown diameter-height were tried to determine. The selection of the regression model was based on the coefficient of determination of the model (R^2) and the standard error of estimate ($S_{y \cdot x}$) (Avery and Burkhart, 1994). In all types of relationships, the first item was accepted as the independent and the second item was accepted as the dependent variable. A confidence level of $p = 0.05$ was used for significance in all statistical analyses; and the analyses were carried out by using Minitab R13 package.

RESULTS

Harmful insects: Inspections on bark samples and catches at the light trap showed that *Ips acuminatus* (Gyll.), *Orthotomicus erosus* (Woll.), *Pityogenes quadridens* (Hartig) (Coleoptera: Scolytidae), *Dendrolimus pini* (L.) (Lepidoptera: Lasiocampidae) and *Sphinx pinastri* (L.) (Lepidoptera: Sphingidae) were determined at stands of 15-45 cm dbh, 50-110 age, 30-50% slope, generally southeast and southwest aspects and at elevation of 1420-2080 m where Scots pine dominated (Simsek, 2002).

Soil analysis: Soil texture of study area was sandy-clay and clay (45-46% sand and 40-47% dust), 6.36-6.55 pH (slightly acidic), poor in lime (1.3%) and poor in organic matter (3.99-0.90%).

Tree height-DBH relationship: The regression analysis indicated that a second-degree regression model established between these two variables and it was statistically significant ($F = 1032.50$; $p<0.001$). The regression equation was:

$$H = -30.0000 + 3.1800\,(DBH) - 0.0424\,(DBH)^2 \quad (1)$$

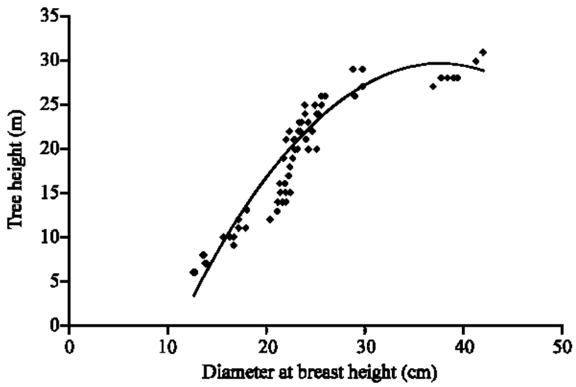

Fig. 1: The relationship between tree height and DBH

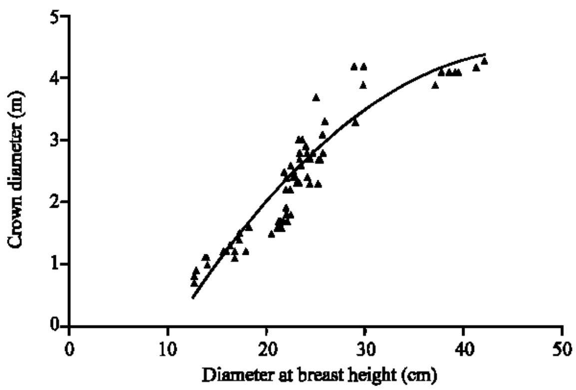

Fig. 2: The relationship between crown diameter and DBH

It was found that the coefficient of determination and the standard error of estimate were $R^2 = 0.893$ and $S_{H, DBH} = 2.262$, respectively. The regression coefficients (b_0, b_1) were also significant ($p<0.001$). Thus, it is seen that there is a strong positive, nonlinear relationship between tree height and DBH (Fig. 1). Because, DBH explained 89.3% of the observed variation in tree height.

The crown diameter-DBH relationship: At the end of the regression analysis, it was determined that a second-degree regression model established between these two variables and it was statistically significant ($F = 855.32$; $p<0.001$). The regression equation was:

$$CD = -3.06000 + 0.32400\,(DBH) - 0.00348\,(DBH)^2 \quad (2)$$

It was found that the coefficient of determination and the standard error of estimate were $R^2 = 0.874$ and $S_{CD, DBH} = 0.3491$, respectively. The regression coefficients (b_0, b_1 and b_2) were also significant ($p<0.001$). Thus, it is seen that there is a strong positive, nonlinear relationship between tree crown diameter and DBH (Fig. 2). Because, DBH explained 87.4% of the observed variation in crown diameter.

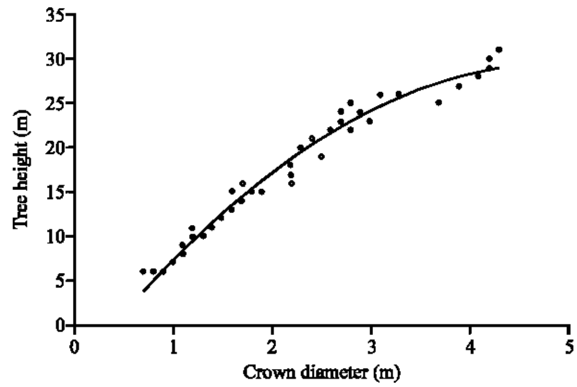

Fig. 3: The relationship between crown diameter and tree height

The crown diameter-tree height relationship: According to the regression analysis, it was determined that a second-degree regression model established between these two variables and it was statistically significant ($F = 5134.62$; $p<0.001$). The regression equation was:

$$H = -5.44 + 14.20\,(CD) + 1.44\,(CD)^2 \quad (3)$$

It was found that the coefficient of determination and the standard error of estimate were $R^2 = 0.977$ and $S_{H, CD} = 1.058$, respectively. The regression coefficients (b_0, b_1 and b_2) were also significant ($p<0.001$). Thus, it is seen that there is a strong positive, nonlinear relationship between crown diameter and tree height (Fig. 3). Because, the crown diameter explained 97.7% of the observed variation in tree height.

DISCUSSION

In this study, we determined that diameters of Scots pines vary between 15-45 cm, ages between 50-110, slopes vary between 30-50%. Thus, we reached the conclusion those areas where Scots pines grow at north and southwest aspects may negatively be affected from water stress due to poor soil conditions and insufficient precipitation. Thus, the areas where Scots pines grow and specified conditions rule are appropriate for bark beetle breeding. Furthermore, determination of bark beetles (*I. acuminatus*, *O. erosus* and *P. quadridens*) supports this conclusion. Results of previous studies on this subject (Acatay, 1963; Besceli, 1969; Capecki, 1982; Chararas, 1975; Canakcioglu and Mol, 1998; Kaczmarek *et al.*, 1992; Klein, 1984; Schimetschek, 1953; Sekendiz, 1987; Starzyk and Lusczak, 1982; Simsek, 2000, 2001, 2002, 2003; Simsek and Oner, 2002; Simsek and Ozdemir, 2000; Tiberi, 1997; Toper, 2000; Tsankov *et al.*, 1994; Yuksel, 1997; Witrylak, 1995) are similar to support present findings. In this study 3 bark beetles (*I. acuminatus*, *O. erosus*, *P. quadridens*) and 2 lepidopterous insects (*D. pini* and *S. pinastri*) have been determined to be the most important pests of Scots pine in study area. Previous studies show that *D. pini* is an important harmful insect of pines in Turkey, Norway and Russia (Adolfsson, 1984; Grimal'skii and Entin, 1980; Malyi, 1978). Outbreaks of this insect are related to climatic conditions (Lesniak, 1976; Klimetzek, 1971) and its damage adversely affects the radial growth (Ierusalimov, 1977). *S. pinastri* is a main pest in The Netherlands (Meerman and Schouten, 1980). This moth may exist in pine forests up to 1600 m elevation at Alps and yet it may exist until 200 m elevation in Lebanon (Pittaway, 1993). *S. pinastri* defoliated pines in Marmara Region in Turkey (Mol and Avci, 1997) and Simsek (2002) collected many samples during his studies in Ilgaz.

It was determined that the regression models established between DBH, height and crown diameter variables of Scots pines in the research area were statistically significant ($p<0.001$). That the R^2 value is more than 0.50 in the models established indicates that there are strong relationships between these three variables (Kalipsiz, 1981). The strongest relationship determined was the crown diameter-tree height relationship ($R^2 = 0.977$), followed by the tree height-DBH ($R^2 = 0.893$) and crown diameter-DBH ($R^2 = 0.874$) relationships, respectively.

The relationships between height and DBH were investigated in many studies (Akalp, 1983; Demirci and Gul, 1993; Zhang, 1997; Peng, 1999; Peng *et al*., 2001; Colbert *et al*., 2002). In these studies carried out on various tree species, it was determined that there was a strong relationship between height and DBH and this relationship was described by various nonlinear regression models. Kalipsiz (1984) stated that the relationship between height and DBH was in the shape of a parabola segment in even-aged and one-storied stands and could be described by a second-degree polynomial (parabola); this relationship was in the shape of S-curve in selection forests. In the present study, the height-DBH relationship was described by a second-degree polynomial model as suggested by Kalipsiz (1984).

There are many studies investigating the relationships between crown diameter and DBH (Akalp, 1983; Sun, 1977; Gering and May, 1995; Hasenauer, 1997; Bragg, 2001; Avsar, 2004). Francis (1988) and Foli *et al*. (2003) also investigated the crown radius-DBH and crown diameter-bole diameter (3.96 m above ground) relationships, respectively. In these studies carried out on various tree species, it was determined that there was a strong relationship between crown diameter and DBH (bole diameter) or crown radius and DBH and this relationship was generally described by the simple linear model, nonlinear models were also used in some studies. In the present study, the crown diameter-DBH relationship was described by a second-degree polynomial model.

On the other hand, Hasenauer (1997) determined that the relationship between crown diameter and height was generally strong in various tree species and this relationship could be described by the simple linear model. In the present study, the crown diameter-height relationship was described by a second-degree polynomial model as in the crown diameter-DBH relationship.

From the results of present study, it was determined that heights and crown diameters could be estimated by means of DBH, of which measurement is easy, in the studies of ground-based forest inventory and stand structure determination to be made in the pure Scots pine stands of the research area. The crown diameter-tree height relationship, which is stronger than the crown diameter-DBH relationship, should be used in the estimate of crown diameter. In addition, the all relationships (tree height-DBH, crown diameter-DBH and crown diameter-tree height) can be described by the second-degree polynomial model ($Y = b_0 + b_1X + b_2X^2$) in Scots pines of the research area.

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