

Genus *Quercus*: An Overview

Younas Rasheed Tantray¹, Mohammad Saleem Wani², Ashiq Hussain³

¹Department of Botany, Punjabi University Patiala, Punjab (India)

²Department of Botany, Punjabi University Patiala, Punjab (India)

³College of Forestry Allahabad Agricultural Institute, Allahabad U.P. (India)

ABSTRACT

The genus *Quercus* comprises over 600 species of trees and shrubs which are mostly deciduous and are found in a variety of habitats. In the current literature, Oaks are dealt with either as a solitary genus with two sub genera (*Quercus* and *Cyclobalanopsis*), or as two separate genera (*Quercus* and *Cyclobalanopsis*). However, in the Western Hemisphere, the genus *Quercus* has been divided into three distinct groups- the white Oaks, the red or black Oaks and the intermediate or golden Oaks. The genus is local to the Northern Hemisphere extending from cool mild to tropical scopes in America, Asia and Europe. North America contains the biggest number of Oak species. Species of genus *Quercus* are overwhelmingly monoecious with male and female blossoms borne on two types of inflorescences, very occasionally they bear hermaphroditic flowers. The species of genus *Quercus* play an important role in maintaining the structure and functioning of various forest communities therefore have a significant ecological role.

Keywords: *Distribution, economic importance, Quercus, northern hemisphere, reproductive biology*

I. INTRODUCTION

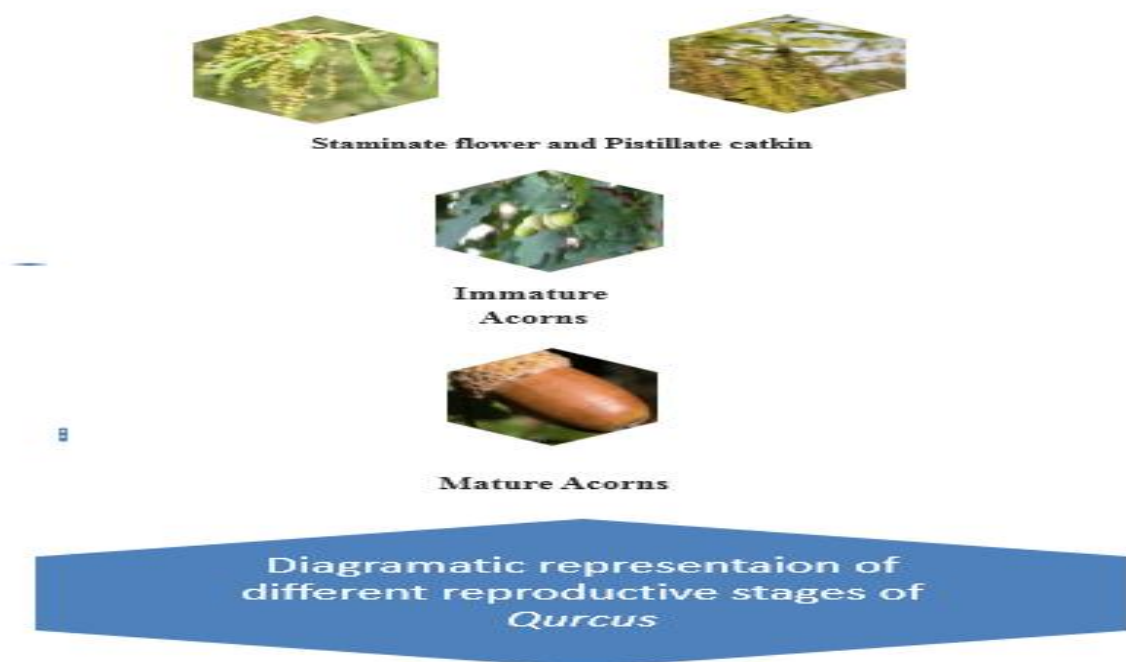
Quercus L. (Oak) belongs to family Fagaceae containing very important woody plants which are either shrubs or trees having simple alternate leaves and characterized by their wood, wind pollinated flowers, acorns as fruits and their ability to survive for centuries. The genus *Quercus* also known as Oak, consists about 600 species worldwide. The genus *Quercus* is one of the most imperative clades of woody angiosperms in the northern half of the globe in terms of species diversity, ecological dominance and economic value. Oaks are dominant members of a wide variety of habitats, including temperate deciduous forests, temperate and sub-tropical evergreen forests, sub-tropical and tropical savannah and subtropical woodlands. Oaks are found in a wide assortment of living spaces and favour loamy, well drained soils. The roots are very extensive, connecting no less than three times the stature of the tree and down as profound as 15-40 ft (4.6-12.2m), contingent upon site conditions. Oaks fluctuate in size from little shrubby species to trees with lofty measurements. The tallest Oak, coming up to 123 ft (37.5m), with an outline of 21.6 ft (6.06m) and a shade spread more than 83.6 ft (25.5m) is a black Oak found in Warrensville Heights, Ohio.

The genus *Quercus* initially shows up in the fossil record in the early Tertiary of North America around 50-55 million years back [1, 2]. The genus *Quercus* additionally incorporates *Fagus* (beeches), *Castanea* (the genuine chesnuts), other "castaneoid" genera (*Chysolepis*, *Castanopsis* and *Lithocarpus*), and three monotypic tropical genera (*Trignobalanus*, *Formanodendron* and *Colombobalanus*). In the current writing, Oaks are dealt with either as a solitary genus with two sub genera (*Quercus* and *Cyclobalanopsis*), [3] or as two particular genera

(*Quercus* and *Cyclobalanopsis*). In the flora of China, the two genealogies were isolated as particular genera, with 35 species placed under *Quercus* and 69 species under *Cyclobalanopsis* inside China [4]. However, in the New World, the genus *Quercus* has been partitioned into three particular groups- the white Oaks (section *Quercus*, sometimes referred to as sub genus or section *Leucobalanus* or *Lepidobalanus*), the red or black Oaks (section *Lobatae*; also sometimes referred to as subgenus or section *Erythobalanus*), and the intermediate or golden Oaks (section *Protobalanus*) [3, 5, 6]. A fourth group, *Cerris* is restricted to Eurasia and North Africa. North America contains the largest number of Oak species, with roughly 91 present in the united states, while Mexico has 160-165 species of which 109 are endemic. In India, the genus *Quercus* is spoken by 35 species which are basically confined to the Himalayan locale [7] between 1000-3500m heights and are the overwhelming, climax tree species of the wet mild forests. Five species of evergreen Oak namely *Quercus glauca* (Phaliyant/harinj), *Q. leucotrichophora* (banj), *Q. lanuginosa* (rianj), *Q. floribunda* (moru) and *Q. semecarpifolia* (kharsu) grow naturally in the Western Himalaya. In the Western Himalayas, the genus *Quercus* has a lot of conservation significance and provides numerous ecosystem services such as conservation of soil, water and native flora and fauna, The Oak forests are the sources of fuel wood as well as fodder.

II.REPRODUCTIVE BIOLOGY

Depending fundamentally on wind fertilization, huge amounts of pollens are produced in the male blooms (25-100 for every catkin) each spring. The female blooms tucked unnoticeably in the hubs of pivotal twigs develop somewhat later, staying away from self-fertilization. Either single or bunches of a few oak seeds start forming. Most trees start oak seed creation following 20 years. Harvest creation shifts yearly as per various elements, yet an individual tree can deliver more than 5,000 nuts in a decent year. Of these, about 25% are probably going to be plagued with weevils, making them unappetizing and unviable. Species of the genus *Quercus* are predominantly monoecious with distinct male and female flowers borne on two types of inflorescences; very occasionally they bear hermaphroditic flowers or inflorescences [8, 9, 10, 11]. Sexual reproduction in *Q. robur* was first described in detail by [12]. Additional studies of embryo development have been reported for the following species: *Q. ilex* [13] and *Q. trojana* [14]. In addition the development of the embryo sac in *Q. rober* have been investigated by [15] and the morphology of flowering and seed development in *Quercus* by [16] and [17]. Male flowers are grouped in catkins which develop in the axils of either the inner bud scales or the first leaves, in the lower part of the branches produced in the same year. Staminate inflorescences are initiated in late spring, flowers develop in early summer and meiosis occurs in the following spring, giving rise to binucleate pollen grains immediately prior to the emergence of catkins [8, 10, 18, 19, 20, 21] . For a given tree, if weather conditions are suitable, catkin growth is achieved 1-2 weeks after bud opening, and pollination is completed in 2-4 days [8, 18, 22, 23]. In deciduous Oaks, leaf expansion ceases during the release of pollen, which allows free movement of pollen [18].



Female flowers appear in the axils of leaves produced in the same year. They are produced on a short stalk and become visible a few days after the emergence of the male catkins [24]. Inflorescence primordia are difficult to distinguish from lateral bud primordial before late summer, hence the exact time of the initiation of pistillate inflorescences is difficult to determine. As hermaphrodite flowers are known to occur occasionally, [10] has hypothesized that their initiation may occur in late spring, when the staminate inflorescences develop. Female flowers develop in late winter or early spring [10, 21]. Each flower is included in a cupule, which is regarded as homologous to a third-order inflorescence branch [25, 26]. During elongation of the stalk, 3-5 styles emerge from the cupule and become reddish and sticky when receptive [13, 24]. Stigma receptivity for a single flower may last up to 6 days and 10-14 days for the pistillate inflorescence as a whole [27]. Stigma receptivity for a given tree was found to be roughly 15 days in *Q. ilex* [23]. In annual acorns, e.g. in the white oak section of the genus, meiosis and fertilization of ovules occur 1 or 2 months after pollen deposition. In biennial acorns, eg. in most of the American red oak section, the delay is about 13-15 months [8, 13, 15, 28, 29]. In several species, such as *Q. coccifera* and *Q. suber*, annual and biennial, or even intermediate acorns, occur on distinct individual trees [30]. One embryo sac is usually initiated per spore and this develops in the nucellus. Rare cases of polyembryony, due to the development of more than 1 embryo sac per nucellus, or the occurrence of 2 nucelli per ovule, have been reported [8, 13,15]. At fertilization, the pollen tube enters the ovule through the micropyle [15] after which 1 of the 6 ovules in the ovary develops into a seed. This ovular dominance occurs during early embryo growth [8]. [31] reported that 4 types of abortive ovules occur in *Q. gambelii* Nutt, with an average of 2.7 ovules per ovary that do not develop into seed due to lack of fertilization. In other cases, ovule abortion was due to zygote or embryo failure, or the absence of an embryo sac or the occurrence of an empty one. For these reasons, [31] proposed that the first fertilized ovule either suppresses the growth of the other fertilized ovules or prevents their fertilization. After fertilization, the acorns mature within about 3 months, then fall [13, 28]



Recalcitrant seeds, such as those of *Q. robur*, species are characteristically shed from the mother plant with high moisture content and thereafter remain sensitive to desiccation, losing viability as they lose water. Their inability to survive drying renders them unsuitable for orthodox seed storage [32]. Acorns of the subgenus *Erythrobalanus* usually exhibit delayed germination, commonly described as dormancy. As dormancy is overcome by stratification or other methods, metabolic activity increases within the acorns [33]. Acorns of the subgenus *Lepidobalanus* (white oaks) do not show complete dormancy. There is epicotyl dormancy in some white oak species, notably white, chestnut, and overcup [34]. Red and black oaks (subgenus *Erythrobalanus*) exhibit variable dormancy. Not only do species differ in dormancy, but within a species differences can be due to geography or altitude. [35] for instance, found that chilling requirement for germination of northern red oak increased with latitude and altitude of seed source. A prominent contemporary concept of seed dormancy involves the interaction of plant growth regulators. These regulators may be either inhibitors or promoters and act together to influence the net result of germination or dormancy [36, 37] has found that two plant growth regulators in particular act together: indoleacetic acid (IAA) and abscisic acid (ABA). Quantitative and qualitative analysis have been made for IAA, ABA, gibberellic acid (GA), and cytokinin in embryos of maturing and stratified water oak acorns [38]. Results of both studies indicated that IAA and ABA levels increase with acorn development but decrease with acorn maturity. IAA content is always greater in the cotyledon than in the pericarp, while ABA is equally distributed between the two. Conversely, cytokinin activity decreases during maturation. Moreover, the cytokinin activity pattern was consistent with the high rate of cell division taking place during maturation. During stratification, IAA decreased from day 10 to day 50. The inhibitor-promoter balance in the embryo axis changed between day 30 and day 50, as ABA increased and GA increased [38]. Dormancy in *Q. robur* has also been attributed to the pericarp by [39]. They induced germination by removing or clipping the pericarp and concluded that dormancy was the result of inhibited cell expansion. [40] also concluded that the pericarp was significantly involved in dormancy of *Q. robur*, and [41] found pericarps to inhibit germination of four red oak species. Pericarp removal from acorns had no significant effect on seedling growth of water oak, but it increased acorn germination from 10 to 55 percent [42]. [43] results with water oak revealed that, although pericarp or seed coat tissues were not impediments to water uptake, the pericarp might entrap gases which could then affect water uptake. Another possible factor in acorn dormancy is the interaction of seed coat (pericarp) and microorganisms. Microorganisms have been isolated in mixed culture from water oak acorns [44]. The most definitive studies on acorn dormancy are those of [43] on water oak. He concluded that delayed germination (dormancy) was the result of at least three factors: (1) Mechanical strength of the pericarp; (2) chemical inhibition by the pericarp, which was alleviated by stratification for approximately 4 weeks; and (3) slow increase in capacity to imbibe the water required for pericarp rupture.

III. ECONOMIC IMPORTANCE OF GENUS *QUERCUS*

As we know that Oaks are distributed in a wide variety of habitats so they play an important role in maintaining the structure and functioning of various forest communities therefore have a significant ecological role. A vast majority of the species are used as ornamentals for e.g. In North America a few oaks are of decorative scene esteem, including pin oak (*Q. palustris*) and northern red oak (*Q. rubra*). White oak (*Q. alba*) and bur oak (*Q. macrocarpa*) frame pleasant oak forests locally in the Midwest. Numerous oaks local to the



Mediterranean range have economic value: galls formed on the twigs of the Aleppo oak (*Q. infectoria*) are a wellspring of Aleppo tannin, utilized as a part of ink fabricate; commercial cork is acquired from the bark of the stopper oak (*Q. suber*), and the tannin-rich kermes oak (*Q. coccifera*) is the host of the kermes insect, once collected for a color contained in its body liquids. The two economically important Eastern Asian Oak species are: the Mongolian oak (*Q. mongolica*) and the Oriental oak (*Q. variabilis*). The Mongolian oak is an important source of timber and the Oriental oak is a source of a black dye and is also used for ornamental purpose. Other developed ornamentals are the Armenian, or pontic, oak (*Q. pontica*), chestnut-leaved oak (*Q. castaneaefolia*), golden oak (*Q. alnifolia*), Holm, or holly, oak (*Q. ilex*), Italian oak (*Q. frainetto*), Lebanon oak (*Q. libani*), Macedonian oak (*Q. trojana*), and Portuguese oak (*Q. lusitanica*). Prevalent Asian ornamentals incorporate the blue Japanese oak (*Q. glauca*), daimyo oak (*Q. dentata*), Japanese evergreen oak (*Q. acuta*), and sawtooth oak (*Q. acutissima*). The products of *Quercus* (Acorns) give sustenance to little amusement creatures and are utilized to fatten swine and poultry. Red-and white-oak blunder is utilized as a part of development, flooring, furniture, millwork, cooperage, and the generation of crossties, auxiliary timbers, and mine props.

In addition to ecological and aesthetic value, one crucial role of Oaks is that they help in maintaining watershed integrity. The extensive root system of Oaks reduces soil erosion, stabilizes slopes and permit groundwater storage. The capacity of oaks and different trees to decrease air contamination and trap airborne particulates is very much archived. The basic qualities of the wood make oak a standout amongst the most adaptable hardwoods, esteemed by numerous businesses. On account of their immense interest in oak seed creation, oaks assume a basic part in supporting natural life and keeping up local biodiversity. Numerous transient types of feathered creatures and bats perch or home in them, notwithstanding utilizing the nourishment asset. In California, it is evaluated that more than 5,000 types of bugs, more than 80 types of reptiles and creatures of land and water, 150 types of winged animals, and more than 60 types of warm blooded animals depend upon oaks for some piece of their lifecycle. Oak seed or pole creation is such a huge component of most oak biological systems that harvest disappointment can be dangerous for some species. Besides, some species of Oaks are having antibacterial, anti-inflammatory, anti-diabetic and wound healing activity as well.

IV. ACKNOWLEDGEMENTS

The authors are grateful to the University Grant commission, New Delhi for providing financial assistance under JRF to Younas Rasheed (Award letter no. 2121430298 12/8/2015). The authors are also thankful to Head, Department of Botany, Punjabi University, Patiala for providing necessary herbarium and library facilities.

REFERENCES

- [1] W. L. Crepet, and K. C. Nixon. Earliest megafossil of Fagaceae: phylogenetic and biogeographic implications. *American Journal of Botany*, 76, 1989a, 842-855.
- [2] W. L. Crepet, and K. C. Nixon. Extinct transitional Fagaceae from the Oligocene and their phylogenetic implications. *American Journal of Botany*, 76, 1989b, 1493-1505.
- [3] K. C. Nixon. Infrageneric classification of *Quercus* (Fagaceae) and typification of sectional names. In *Annales des sciences forestières*, 50, 1993b, 25s-34s.
- [4] H. Chengjiu, Z. Yongtian, and B. Bartholomew. "Fagaceae." *Flora of China*, 4, 1999, 314-400.



- [5] K.C. Nixon. The genus *Quercus* in Mexico. In: Ramamoorthy TP, Bye R, Lot A, Fa J (eds) Biological diversity of Mexico: origins and distribution. Oxford Univ Press, Oxford, UK, 1993a, 447–458.
- [6] P.S. Manos. *Quercus* section *Protobalanus*. In: Flora of North America Editorial Committee (eds) Flora of North America, North of Mexico, Oxford Univ Press, New York 3, 1997, 470–471.
- [7] R.S. Troup. Silviculture of Indian Trees. Vol. I-III. Clarendon Press, Oxford. 1921.
- [8] G.R. Stairs. Microsporogenesis and embryogenesis in *Quercus*. *Botanical Gazette*, 125, 1964. 115-121.
- [9] J.M. Tucker. Hermaphrodite flowers in Californian Oaks. *Madrono*, 21, 1972, 482-486.
- [10] M. Bonnet-Masimbert. Biologie florale des chênes pédonculés et sessiles (*Quercus pedunculata* Ehrh et *Q sessiliflora* Sal). In: Symp, Régénération et le Traitement des Forêts Feuillues de Qualité en Zone Tempérée. CNRF, 11, 1978, 17-29.
- [11] J.M. Tucker, R.P. Neilson, and H. Wullstein. Hermaphroditic flowering in gambel oak. *American Journal of Botany*, 67, 1980, 1265-1267.
- [12] A.H. Conrad. A contribution to the life history of *Quercus*. *Botanical Gazette*, 29, 1990, 408-418.
- [13] R. Corti. Ricerche sul ciclo riproduttivo di species del genere *Quercus* della flora italiana. IV. Osservazioni sulla embriologia e sul ciclo riproduttivo in *Quercus ilex* L. *Ann. Accad. Ital. Sci*, 8, 1959, 19-42.
- [14] P. Bianco. "Ricerche sul ciclo riproduttivo di specie del genere *Quercus* della flora Italiana. VI. Contributo alla biologia di *Quercus trojana* Webb in Puglia." *Annali Accademia Italiana di Scienze Forestali*, 11, 1961, 59-104.
- [15] H. Hjelmqvist. The embryo sac development of *Quercus robur* L. *Phytomorphology*, 3, 1953, 377-384.
- [16] LaDema Mary Langdon. "Ontogenetic and anatomical studies of the flower and fruit of the Fagaceae and Juglandaceae." *Botanical Gazette*, 101, 1939. 301-327.
- [17] H. S. Turkel, A.L. Rebuck, and A.R. Grove. Floral morphology of white oak. Pa. State Univ. Bulletin, 593, 1955 pp. 14.
- [18] W.M. Sharp, and H.H. Chisman. Flowering and fruiting in the white oaks. I. Staminate flowering through pollen dispersal. *Ecology*, 42, 1961, 365-372.
- [19] A. Tucovic, and M. Jovanovic. Some characteristics of meiosis in common oak (*Quercus robur* L). In: Sexual Reproduction of Forest Trees (Valtion P, ed) IUFRO, Varparanta, Finland, 1970, 41-42.
- [20] M. Hagman. Incompatibility in forest trees. *Proc R Soc Lond Ser. B*, 188, 1975, 313-326.
- [21] S.A. Merkle, P.P. Feret, J.G. Croxdale, and T. L. Sharik. Development of floral primordia in white oak. *Forest Science*, 26, 1980, 238-250.
- [22] A. R. Vogt. Reproduction of the oak. *Ohio Report*, 54, 1969, 19-21.
- [23] R. Lumaret, A. Yacine, A. Berrod, F. Romane, and T.X. Li. Mating system and genetic diversity in holm oak (*Quercus ilex* L Fagaceae). In: Biochemical Markers in the Population Genetics of Forest Trees (Fineschi S, Malvolti ME, Cannata F, Hattemer HH, eds) SPB Academic Publ, The Hague, 1991, 149-153.
- [24] W.M. Sharp and V.G. Sprague. Flowering and fruiting in the white oaks. Pistillate flowering, acorn development, weather, and yields. *Ecology*, 48, 1967, 243-251.



- [25] D.W. Brett. The inflorescence of *Fagus* and *Castanea*, and the evolution of cupules of *Arena*, M. Ricerche sul ciclo riproduttivo di specie del genere *Quercus* della flora italiana. III. The Fagaceae. *New Phytol*, 63, 1964, 96-118.
- [26] A.D. McDonald, Inception of the cupule of *Quercus macrocarpa* and *Fagus grandifolia*. *Canadian Journal of Botany*, 57, 1979, 1777-1782.
- [27] S.S. Pjatniski. On pollination in oaks and the germination of pollen on the stigmas. Dokl Akad Nauk SSSR, 56, 1947, 545-547.
- [28] W.M. Sharp. Evaluating mast yields in the oaks. Pennsylvania State University Agriculture Experiment Station Bulletin 635, 1958, pp. 22.
- [29] R. C. Brown, and H. L. Mogensen. Late ovule and early embryo development in *Quercus gambelii*. *American Journal of Botany*, 59, 1972, 311-316.
- [30] P. Bianco, and B. Schirone, On *Quercus coccifera* L. Variation in reproductive phenology. *Taxon*, 34, 1985, 436-439.
- [31] H.L. Mogensen, Ovule abortion in *Quercus* (Fagaceae). *American Journal of Botany*, 62, 1975, 160-165.
- [32] F.H. Roberts. Predicting the storage life of seeds. *Seed Science and Technology*, 1, 1973, 499-514.
- [33] J.A. Vozzo, and R.W. Young. Carbohydrate, lipid, and protein distribution in dormant, stratified and germinated *Quercus nigra* embryos. *Botanical Gazette*, 136, 1975, 306-311.
- [34] R.E. Farmer. Epicotyl dormancy in white and chestnut oaks. *Forest Science*, 23, 1977, 329-332.
- [35] Jr, Robert E. Farmer "Germination of northern red oak: effects of provenance, chilling, gibberellic acid." Proceedings. 1974.
- [36] R.D. Amen, A mode of seed dormancy. *Botanical Review*, 34, 1968, 1-31.
- [37] M.G. Nikolaeva. On the hormonal nature of the regulation of deep dormancy of seeds. In: Bialobok, S., Suszka, B., eds. Proceedings, international symposium on seed physiology of woody plants. 1968.
- [38] G. M. Hopper, and J. A. Vozzo. Auxin, gibberellic acid and abscisic acid in water oak embryos. In: Proceedings, 7th North American forest biology workshop; 1982 July 26-28; Lexington, KY. Lexington, KY: University of Kentucky and Society of American Foresters. 1982, 327-331.
- [39] L. Jones, and C. L. Brown, Cause of slow germination in cherrybark and northern red oak. Proceedings. Association of Official Seed Analysts, 56, 1966, 82-88.
- [40] G. M. Hopper, D. Smith, and D. J. Parfish. Germination and seedling growth of northern red oak: effects of stratification and pericarp removal. *Forest Science*, 31, 1985, 31-39.
- [41] F. T. Bonner, Water uptake and germination of red oak acorns. *Botanical Gazette*, 129, 1968, 83-85.
- [42] G.M. Hopper. Seed dormancy and germination of northern red oak. Blacksburg, VA: Virginia Polytechnic Institute, 1982, pp.102.
- [43] J.K. Peterson, Mechanisms involved in delayed germination of *Quercus nigra* L. seeds. *Annals of Botany*, 52, 1983, 81-92.
- [44] J.A. Vozzo. Insects and fungi associated with acorns of *Quercus* sp. In: Proceedings, cone and seed insects working party conference; 1983 July 31-August 6; Athens, GA. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station, 1984, 40-43.