A review of the insect pests of elm, with a detailed study of the biology of the native elm bark beetle (Hylurgopinus rufipes Eich)

William Bernard Becker
University of Massachusetts Amherst

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A REVIEW OF THE INSECT PESTS OF ELM, WITH A DETAILED STUDY OF BIOLOGY OF THE NATIVE ELM BARK BEETLE, HYLURGÖPINUS RUFIPES EICH.

BECKER - 1937
A Review of the Insect Pests of Elm, with a Detailed Study of the Biology of the Native Elm Bark Beetle, Hylurgopinus rufipes Eich.

By

William B. Becker

Submitted as a Thesis to the Faculty of the Graduate School In Partial Fulfillment of the Requirement for the Degree of Master of Science

Massachusetts State College

June 1937
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INTRODUCTION

The purpose of this study is to gain a better knowledge of the life history and habits of the native elm bark beetle, *Hylurgopinus rufipes* Eich., in order to determine the probability of it becoming an important vector of *Ceratostomella ulmi*, the causal organism of the Dutch elm disease. Little information has been available regarding the life history and habits of this beetle which, before the introduction of the Dutch elm disease, was considered of only secondary importance because it was not known to attack healthy trees. Now that the Dutch elm disease is established on this continent, the beetle comes under suspicion as a possible vector, for it breeds in weakened and recently killed elms, some of which may harbor *Ceratostomella ulmi* in localities where the Dutch elm disease exists, later attacking other elms for feeding and egg-laying purposes. In fact, when its habits are compared with those of the closely related but introduced European elm bark beetle, *Scolytus multistriatus* Marsh., which make it the most important vector of the disease in this country, the two are found to be similar. *Scolytus multistriatus* has been associated with *Ceratostomella ulmi* in Europe for a number of years and the relationship between them has been studied extensively. The native species only came in contact with the disease after the latter was introduced into this country about 1930 and the relationship has not been studied to the same extent. However,
it has been shown experimentally that adults of *Hylurgopinus rufipes* from diseased elms can carry the spores, and the fungus has been recovered from the new galleries made by those beetles in previously non-infected logs (Collins, Buchanan, Whitten, and Hoffman, 1936; Britton, 1935; Clinton and McCormick, 1935).
IMPORTANCE OF ELMS

There are six species of elms indigenous to the United States which attain tree size. Three of these are of first importance as ornamentals or producers of lumber. They are the American or White Elm (*Ulmus americana* Linn.), the Red or Slippery Elm (*U. fulva* Michaux), and the Rock or Cork Elm (*U. racemosa* Thomas). The other three native species are of minor importance and occur in the South. These are the Winged Elm (*U. alata* Michaux), Cedar Elm (*U. crassifolia* Nuttall), and Red or September Elm (*U. serotina* Sargent). In addition, several other species of elms have been introduced into this country from abroad.

The natural distribution of the six native species is outlined by Sudworth (1927) as follows:

"*Ulmus americana* Linn. From southern Newfoundland to Lake Superior (north shore) and to the eastern base of the Rocky Mountains (here up the Saskatchewan River to latitude 54° 30'); south to Florida (DeSoto County); west to North Dakota (Turtle Mountains), South Dakota (Black Hills), western Nebraska, central Kansas, Oklahoma, southwestern Arkansas (Rich Mountain), and Texas (Coke County).

"*Ulmus racemosa* Thomas. From Quebec (eastern townships) through Ontario, and south through northwestern New Hampshire to southern Vermont; and to northern New Jersey; westward through northern New York; southern Michigan, central Wisconsin (Lake Mendota, near Madison), and southwestern Minnesota to northeastern Nebraska (Meadville), western Missouri, eastern Kansas, and middle Tennessee.

"*Ulmus fulva* Michaux. From Lower St. Lawrence River (Orleans Island) through Ontario to South Dakota and eastern Nebraska, southeastern Kansas, southwestern Arkansas, and
Oklahoma; south to western Florida, central Alabama, and Mississippi, western Louisiana and Texas (Kerr and Comal Counties).

"Ulmus alata Michaux. From southern Virginia to central Florida (Lake County), and from southern Illinois and Indiana through western Kentucky and Tennessee to the Gulf, and west through southern Missouri, Arkansas, eastern Oklahoma, and Texas (Guadaloupe River).

"Ulmus crassifolia Nuttall. From Mississippi (Sunflower River) through southern Arkansas and Texas (from coast to the Pecos River) to Mexico (Nuevo Leon).

"Ulmus serotina Sargent. Range imperfectly known at present; known now, at different stations, only from southern Kentucky and Tennessee to northeastern Georgia, northern Alabama, northwestern and southwestern Arkansas and eastern Oklahoma; southern Illinois (Richland County)."

The most important of the native elms is the American elm, Ulmus americana. It has been planted extensively over its natural range and has been introduced onto the west coast as an ornamental shade tree. People prefer it over many other shade trees because of its deliquescent form which throws a moderate shade over the ground, yet leaves enough space beneath its branches for free movements of air and traffic. It also permits the suburban type of home with peaked roof to be erected beneath the arches formed by branches of adjacent elms. Because of these and other characteristics of growth and adaptability to street, park and lawn planting, Fernow (Herrick, 1935) rates it as one of the most valuable of the common shade trees in the country.

Numerous shade tree authorities and literary people praise our elms, many pointing out the beauty of elm-shaded New England villages and historical elms scattered over the country. Some
persons place a monetary value on them. Barraclough (1935) valuates the estimated 100,000 elms within town limits in New Hampshire at $3,000,000. Curtis May (1934) says that 50,000 elms in only five cities in northern New Jersey represent thousands of dollars invested in planting, care, and real estate values. Michaux (Illick, 1924) calls the American elm the most magnificent "vegetable" of the Temperate Zone. One may realize the importance of our elms by visualizing the appearance of the country stripped of them. This fact is especially true of New England, New York, and Michigan, where the elms are said to attain their best growth. (Mulford, 1926).
Although the American elm is ranked among the highest in shade tree value by Fernow, it is placed twentieth by Howard in a list of twenty-six common shade trees rated on the basis of resistance to insect attack. Its valued rating is 1.25. Those trees showing the highest resistance to insect attack are given a rating of 3.0; those showing least resistance to insect attack are rated at 0.10 (Herrick, 1935). The low resistance of elms favors the spread of an insect-borne plant disease like the Dutch elm disease. Leaf feeding insects may defoliate an elm for a few consecutive years and thereby reduce its vitality so that wood and bark-boring insects may attack it. Information available on the Dutch elm disease to date suggests that elm bark beetles are the chief vectors of the disease. A study of their bark borning habits shows why this is possible.

The breeding and feeding habits of each individual species of insect determines its importance as a vector of a disease. Among the factors to be considered are the degree of contact the insect has with the diseased portions of the tree, the condition of the host which is needed for the insect's attack to occur, the manner in which it attacks the tree, the number of generations produced each year, the abundance of the insect, and the effect of the physical and biotic environment on both the insect and the organism causing the disease. An essential point to be considered when estimating the importance of insects as
Vehicles of disease is: to what extent can the causal organism of the disease be spread by the wind and other possible agents of dissemination without the help of the insects? It should be remembered that when the insects emerge from a diseased tree and attack a healthy tree, they are substituting the direct and highly successful wound inoculation method for the "hit and miss" wind dispersal method. When the fungous organism which causes a plant disease is of a sticky nature and is not produced, to any extent, on exposed portions of the tree, a condition which would not enable it to be spread easily and profusely by the wind, the fungus must depend upon agents which do come in contact with it for transmission to other plants.

The Dutch elm disease fungus, *Ceratostomella ulmi*, is at present considered to be of this nature. The habits of elm bark beetles are such that when they are contaminated with the fungus they can successfully inoculate other elms with the fungus.

Elm bark beetles have not always been associated with trees infected with *Ceratostomella ulmi* so a study of the relationships of other insects to the disease may prove valuable. Since other wood-boring insects attack diseased portions of the trees, they should be regarded as possible factors in the spread of the disease. This is especially true of the Coleoptera, many of which attack the woody tissues in both the larval and adult stages. The leaf-feeding forms are not considered probable vectors of the disease.
Numerous insects of various orders and several mites attack elms. A few species are peculiar to the elms. A large number attack several families of trees with equal vigor. The vast majority recorded from elms, however, are only occasional pests, many of the latter being rare. Following is a list of species known to attack elms in America. It includes all the economically important pests and most of those which are unimportant or rare. From this list, one may get an idea of the many and varied types of insects which have been recorded from elms. Insects and mites associated with elm pests as scavengers, parasites, and predators have been omitted. The pests have been grouped according to the type of injury produced. The individual species are listed under the order to which they belong.

The economically important pests of elm are noted **. Those which are occasionally abundant and cause local outbreaks are noted *. Those which are unimportant and rare are merely listed by their scientific names.
I. Insects attacking woody parts of elms.

A. Boring insects.

Coleoptera

Alaus oculatus L.  
Anthaxia viridicornis Say  
A. viridifrons Gory  
Bostrichus bicorns Web.  
Buprestis rufipes Oliv.  
Catogenus Rufus Fabr.  
Chrysobothris femorata Oliv.  
Cucujus clavipes Fabr.  
Dendrophagus cyngaei Mann.  
Dicerca divaricata Say  
Dorcas parallelus Say  
Dryopus sexfasciatus Say  
Dularius brevilineus Say  
Eubera quadrigeminita Say  
Eupogonius subarmatus Lec.  
Eupsalis minuta Druech.  
Goes pulverulentus Hald.  
Hister Lecontei Mars.  
H. parallelus Say  
** Hylurgopinus rufipes Eichh.  
Hypermalus villiosus Fabr.  
Leptura emarginata Fabr.  
Lymexylon sericeum Harr.  
** Magdalis armicollis Say  
** N. barbita Say  
Micracis langstani Blackm.  
Monarchrum mall Fitch.  
** Neoclytus acuminatus Fabr.  
** N. capraea Say  
N. erythrocephalus Fabr.  
N. scutellaris Oliv.  
** Oderea tripunctata Swederus  
** Oncideres cingulatus Say  
O. texanus Horn.  
Omoderma eremicola Knoch.  
Otidocephalus chevrelati Horn.  
Parandra brunnea F.  
Phloeophagus minor Horn.  
Phyllobius oblongus L.  
Physoconemum brevilineum Say  
Platypus compositus Say  
Saperda lateralis Fabr.  
** S. tridentata Oliv.  
S. vestita Say
**Scolytus multistriatus** Marsh.
S. sulcatus Lec.
*Stenocelis brevior* Boh.
*Synchroa punctata* Newman
*Teneboroides corticalis* Melsh.
*Trichodesma gibbosa* Say
*Uliota dubius* Fabr.
*Xyloterinus politus* Say
*Xylotrechus colonus* Fabr.
*Ligyrus gibbosus* DeG. (Root feeder)
*Polycrusus impressifrons* Gyll. (Root feeder)

**Lepidoptera**
*Prionoxystus robiniae* Peck.
*Zezura aesculi* L.
*Z. pyrina* L.

**Hymenoptera**
* Tremex columba* L.
*Camponotus herculeanus* var. *pennsylvanicus* DeG.

**Isoptera**
*Reticulitermes flavipes* Kollar

**Diptera**
*Ctenophora apicata* O.S.
*Oligoncus ulmi* Felt

**B. Sucking Insects**

**Homoptera**

**Suckle Insects**

*Aspidiotus encylus* Putn.
*Asp. perniciosus* Comst.
*A. ulmi* Johnson
*Chionaspis americana* Johnson
*Coccus citricola* Comp.
*Eulecanium canadense* Ckll.
*E. caryae* Fitch.
*E. nigrofasciatum* Perg.
*Gossyparia spuria* Moseer.
*Lecanionus corni* Bouche
*Lepidosaphes ulmi* L.
Mytilaspis pomorum Bouche
Phenacoccus acericolus King
(Also called a mealy bug)
Pseudoaonidia duplex Kelli.
Pulvinaria innumerabilis Rathvon

Aphids

Eriosoma crataegi Oestland
E. pyricola Baker & Davidson
** E. rileyi Thomas
* Longistigma caryae Harr.

Hemiptera

Lopidea heidemanni Kngt.
Lygos Invitus Say

C. Injury produced by oviposition habits.

Homoptera

* Ceresa bubalus Fabr.
Tibicen chloromera Walk.
T. linnell Smith & Grossbeck

Orthoptera

Hapithus agitator Uhler
Gecanthus niveus Serville

II. Insects and mites attacking the leaves of elms.

A. Chewing Insects

Lepidoptera

Abbotana clementaria Abb. & Sm.
** Alsophila pometaria Harr.
Apatela americana Harr.
A. funeraria Gr. & Rob.
A. grisea Walk.
A. impleta Walk.
A. interrupta Guen.
A. morula Grt.
A. occidentalis G. & R.
A. ulmi Harr.
A. vinnula Grt.
Archips argyrospila Walk.
A. rasana L.
Argyrostia austerella Zeller
Automera io Fabr.
Bactra ? argutana Clem.
Basilarchia arthemis Dru.
Basilona imperialis Drury
Bomolocha abalilenalis Walk.
Cacoecia argyrospila Walk.
Canarsia ulmiarrossorella Clem.
Ceratomia amyntor Hubn.
Charadra deridens Guen.
Datana contracta Walk.
D. ministra Dru.
Deilephila lineata Fabr.
Deilephila bella L.
Euchlaemis Imperialis Drury
Edema albifrons Abb. & Sm.
Ennomos magnarius Guen.
* E. subsignarius Hubn.
Epirrita dilutata Hubn.
Episimus argutanus Clem.
* Frannis tiliaria Harr.
Euchoeca albifera Walk.
Euclea chloris H. & S.
Bulia triferana Walk.
Eustoma diversilineata Hubn.
Falcaria bilineata Pack.
Gluphisia septentrionalis Walk.
G. trilineata Pack.
Graptotheca laticinerea Grote
Halisidota caryae Harr.
H. tessellaris S. & A.
** Hamadryas antiope L.
Hemerocampa definita Pack.
** H. leucostigma S. & A.
Heterocampa bilineata Pack.
Hibernia tiliaria Harr.
Hulastea undulatella Clem.
Hyperchiria io Fabr.
** Hyphantria cunea Drury
Ichthyura americana Harris
Lagoa crispata Pack.
Limenitis arthemis Drury
Lochmoeus sp.
Lophoderus triferanua Walk.
Lycia cognataria Guen.
Malacosoma americana Fabr.
M. disstria Hubn.
Mesoleuca intermediata Guen.
Metanema quercivoraria Guen.
Metrocampa praegrandaria Guen.
Nephopteryx ulmi-arrossorella Clemens
N. undulatella Clemens
Nerice bidentata Walk.
** Nygmia phaeorrhoea Don.
Olene plagiata Walk.
Opheroptera boreata Hubn.
** Paleocrita vernata Peck.
Paonia excaecatus Abb. & Sm.
Paraphia unipuncta Haw.
Parasa choloris H.S.
Parergyia clintonii G. & R.
Percnoptilota flaviata Hubn.
Petrophora diversilineata Hubn.
Phigalia titea Cram.
Platysamia cecropia Linn.
Polygonia comma Harr.
P. *interrogationis* Fabr.
P. *prognae* Cramer
** Porthetria dispar Linn.
Samia cecropia Linn.
S. *gloveri* Strecker
Schizura concinna S. & A.
S. *ipomoeae* Doubl.
S. *unicornis* S. & A.
Selidoesa umbrostalium Guen.
Sisyrosa textula H. & S.
Smerinthus excocatus Abb. & Sm.
S. *geminatus* Say
S. *jamaicensis* Dru.
Telea polyphemos Cram.
* Thyridopteryx ephemeraeformis Haw.
Toype velleda Stoll.
Tortrix (Cacoccia) conflictana Walk.
Utetheisa bella Linn.

Coleoptera

Brachys aerosa Mels.
B. ovata Weber
Chrysomela multiguttata Stal.
C. scalaris Lec.
Conotrichelus anaglypticus Say
Cotalpa lanigera Linna.
Cryptocephalus quadruplex Newm.
Dichelonycha elongata Fabr.
Galeruca calmariaensis L.
** Galerucella luteola Mull.
Graptoleda carinata Germ.
Halicta chalybea Illiger
• H. ulmi Woods
Macrodactylus subspinusus Fabr.
* Monocota coryli Say
Phloeophagus minor Horn.
Phyllophaga (Lachnosterna) anxia Lec.
F. drolei Kby.
F. fusca Froel.
F. Inversa horn.
F. nitida Lec.
F. rugosa Melsh.
Flagioidera versicolor Laitch.
Plocistes ulmi Lec.
Polydrusus impressifrons Gyll.
** Popillia japonica Newman
Systena marginalis Ill.
Xanthonia decemnotata Say

Hymenoptera

** Cimbex americana Leach

Orthoptera

Diapheromera femorata Say

Plecoptera

Taeniopteryx nigripennis Banks
T. pacifica Banks
T. pallida Banks

B. Sucking Insects and mites.

Homoptera

Aphids

Callipterus elegans Koch.
C. sp. Samborn
C. ulmicola Thos.
** Colopha ulmicola Fitch
** Eriosoma americana Riley
** E. lanigerum Hausm.
* E. lanuginosa Hartig
* E. mimica Hottes & Prison
* E. ulmi Linn.
Georgia ulmi Wilson
Lachanus platani Kalt.
L. ulmi Linn.
**Myzocallis ulmifolii** Monell
*Pemphigus ulmi* Licht.
- *ulmifusus* Walsh.
- *walshi* Williams

*Schizoneura compressa* Koch.
*Trisenerura alba* Ratz.

*T.*
- *graminis* Monell
- *pallida* DeGeer.
- *rubra* Licht.
- *ulmi* DeGeer
- *ulmisacculi* Patch

**Scales**

- **Chionaspis americana** Johnson
- **Coccus citricola** Comp.
- **Gossyparia spurla** Modeer
- **Lecanium corni** Bouche
- **Phenacoccus acericola** King
  Also called mealy bugs
- **Phenacoccus dearnessi** King
  Also called mealy bugs
- **Pseudanodia duplex** Ckll.
- **Pulvinaria innumerabilis** Rathvon.
  - *vitis* Linn.

**Aleyrodids**

- **Aleurodes assigi** Penny.

**Leaf hoppers and tree hoppers**

- **Empoa rosae** Linn.
- **Erythroneura ador** McAttee
- **Typhlocyba cymba** McAttee
  - *tricincta* Fitch

**Fulgorid**

- **Poeciloptera pruinosa** Say

**Hemiptera**

- **Lygus invitus** Say

**Acarina (Mites)**

- **Paratetranychus pilosus** C. & F.
- **Tenuipalpus yothersi** McGregor
- **Tetranychus bimaculatus** Harvey
C. Leaf mining and gall forming insects and mites.

Leaf mining insects

Lepidoptera

- **Coleophora limosipennella** Drury
- *Lithocolletes argentinotella* Clem. L.
- *L. ulmella* Chamb.

Coleoptera

- *Odontota nervosa* Panz.
- *Orchestes pallicornis* Say

Hymenoptera

- **Kallofenusa ulmi** Sund.
- *Hylotoma scapularis* Klug.

Diptera

- *Agromyza ulmi* Sund.

Gall formers

Acarina (Mites)

- **Eriophyes** sp. Siebold
  - *E. ulmi* Garman

Cause blasted and aborted buds

Diptera

- **Dasyneura ulmea** Felt
  - *Phytophaga ulmi* Beutlm.
Several elm bark beetles of the family Scolytidae are considered vectors of the Dutch elm disease in Europe. These include *Scolytus multistriatus* Marsh., *Scolytus scolytus* Fab., *Scolytus pygmaeus* Fab., *Scolytus laevis* Chap., *Scolytus solcifrons* Rey., *Scolytus affinis* Egg., *Hylesinus vittatus* Fab., and *Hylesinus kraatzi* Eich. *Scolytus multistriatus* is the only one of these pests established in the United States. This species and *Hylurgopinus rufipes* Eich., the native elm bark beetle, are the only abundant bark beetles of elms in America. Both are known to be capable of infecting elm wood with the fungus which causes the disease (Collins, Buchanan, Whitten, and Hoffman, 1936).

A knowledge of the relationship between bark beetles and fungi is not new. Beetles of the genera *Dendroctonus* and *Ips* are associated with the spread of bluestain fungi. These fungi, which belong to the same genus as that producing the Dutch elm disease, cause large annual losses in the lumber industry, due to the staining of the affected wood.

*Ambrosia* beetles of the family Scolytidae dig long tunnels through the sapwood and heartwood of a tree and depend upon the growth of certain fungi in the tunnels for their food supply. They do not eat the tissues of the wood but feed entirely upon the fungus. The spores of these fungi cling to the bodies of the beetles and are transported from the old to the new galleries where they germinate in "gardens" and develop the "ambrosia" or food of the beetles.
In every case the transmission of the fungus is purely mechanical. The insects concerned come in contact with the casual organism of the disease at an early period of their life cycle when they attack the same parts of the plant which the fungus attacks. The fungus spores adhere to their bodies or get into their digestive tracts while feeding. Later, when the insects attack other plants for feeding or egg-laying purposes, the spores of the fungus are introduced into the tissues of the plant and cause it to become affected by the fungus.
The only native elm scolytid known to be abundant in this country is Hylurgopinus rufipes, commonly known as the native elm bark beetle. A review of literature revealed very little information on the life history and habits of this bark beetle before 1935. The earlier articles appear to be records of casual observations or, at the most, very incomplete observations of its life history. Recent papers (Britton, 1935; Collins, Buchanan, Whitten, and Hoffman, 1936; Herrick, 1935; McDaniel, 1935; Becker, 1935) give a more complete record of the life history, but much yet remains to be done.

Description and Synonomy

Eichhoff (1868) originally described the insect as Hylastes rufipes. Later in the same year, LeConte (1868) described it under the name Hylesinus opaculus. Both names have been applied to the beetle in literature since then. Swaine (1918) established a new genus, Hylurgopinus, of which H. rufipes is the only species.

Recorded Host Plants

The species is chiefly an elm pest. It has been reported, however, on soft maples (Devereaux, 1831), basswood (Swaine, 1918;
Herrick, 1935; Pierson, 1927), tamarack (Harrington, 1884),
arbor vitae (Lintner, 1887), ash (Perkins, 1890; Packard, 1890;
McDaniel, 1935; Lintner, 1881), and cedar (Swenk, 1909).

Distribution

Worthley (1935) reports that H. rufipes has been collected
throughout most of the northern range of the American elm.
Various authors have reported specimens found in Maine, New
Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island,
New York, New Jersey, Pennsylvania, Delaware, Maryland,
"Carolina," Virginia, West Virginia, Kentucky, Ohio, Indiana,
Missouri, Kansas, Michigan, "The Middle States," and in eastern
Canada.

Relationship to the Dutch Elm Disease

Hylurgopinus rufipes Fich. has habits almost identical
with those of the introduced European elm bark beetle, Scolytus
multistriatus Marsh.

In the case of an infected tree in Old Lyme, Connecticut,
no evidence of Scolytus multistriatus was discovered. Instead,
Hylurgopinus rufipes was present in abundance. Ceratostomella
ulmi was cultured from the adults which emerged from this tree.
Some of these adults were allowed to attack healthy elm twigs
under controlled conditions. Subsequent cultures of these
twigs showed the presence of the fungus (Clinton and McCormick, 1935). The following year several other elms in the vicinity of the originally infected tree were stricken with the Dutch elm disease.

Readio (1935) reports that 67.4 percent of the confirmed infestations of Ceratostomella ulmi contained Scolytus multistriatus, 54.4 percent contained Saperda tridentata, and 10.9 percent contained Hylurgopinus rufipes.

Transmission experiments with several bark-infesting insects have been carried on at the Dutch Elm Disease Laboratory at Morristown, New Jersey. With the exception of Scolytus multistriatus and Hylurgopinus rufipes, the results of all experiments were negative. The authors say that occasional positive cultures were obtained with other insects, but these were probably due to "experimental error" in the studies. (Collins, Buchanan, Whitten, and Hoffman, 1936)

C. W. May (1935) reports that 7 out of 19 Scolytus multistriatus adults taken in the field in diseased areas had Ceratostomella ulmi cultured from their bodies, but only 1 out of 7 Hylurgopinus rufipes adults showed its presence. The author adds, however, that the experiment was not carried out on Hylurgopinus rufipes to the same extent. When this work is done, the results may be different.
Methods and Technique

Studies of Adults

*Hibernating Adults.* The outer layers of bark were stripped from parts of the trunks of American elm trees (*Ulmus americana*) and the adults observed in their hibernating tunnels.

*Spring Emergence.* The beetles' activities during the spring period of flight were followed by making observations daily between three and four P.M. in a grove of elms in which adults were abundant the previous winter. Freshly cut elm logs were placed in the grove to attract the beetles for oviposition purposes. Because of the small size and obscure color of the beetles, white cheese cloth was wrapped around the trunks of several trees and logs in order to distinguish them more easily whenever they should crawl or fly about. The air temperature was recorded at the time of each observation so that a correlation could be made between it and the beetles' activities.

When the trap logs were attacked, the bark surfaces were closely examined for evidence of the beetles' activities. After they had dug beneath the surface of the bark, strips of bark were removed and placed between two pieces of glass to observe the construction of the egg galleries on the inner surface of the bark.

*Summer Emergence.* When pupae were found beneath the bark, sections of elm logs were caged to catch the adults on emergence.
The logs were waxed on both ends to conserve moisture and placed in large glass cylinders measuring twelve inches in diameter. The ends of the cylinders were covered with thin voile cloth and secured with thick rubber bands and twine. The cylinders were laid horizontally to permit free circulation of air. They were in the moderate shade thrown by the surrounding elms.

For supplementary rearing purposes glass cylinders, standard wire-mesh rearing cages, and large battery jars were used in the laboratory. Soil was placed in the bottom of each and regularly watered in order to moisten the logs which were placed vertically in this soil at the bottom of the cages and jars. The top ends of these logs were waxed to conserve the moisture in them.

The newly emerged generation of adults from the caged material was collected by using a suction bottle. The suction bottle consists of a small bottle with two glass-tipped rubber tubes inserted through a two-holed rubber stopper. The end of one tube is placed in the worker’s mouth and the other is placed over one of the tiny beetles. Suction through one tube draws the beetle into the bottle through the other tube. A tiny piece of wire-mesh screen clued to the bottle end of the tube leading to the operator’s mouth prevents the beetles from entering the mouth. Then counts are made the cloth is removed from a jar and the beetles rapidly collected in the suction bottle. This method is possible because the beetles are usually slow to take flight.
Studies of Eggs.

Strips of bark were removed from logs and examined microscopically to study the eggs in the galleries.

Studies of Larvae.

After egg galleries were started in the trap logs, development within the bark was observed periodically by removing a strip of bark from a log and counting the larvae present and measuring the widths of their heads to determine approximately the stage of larval development (Dyar, 1890). Mature larvae which had stopped feeding and were ready to pupate could be distinguished from the immature ones during their active season because they were entirely white in color, no food being visible through the body wall as with immature, feeding larvae.

Studies of Pupae.

Mature larvae were removed from the bark and placed in glass vials suspended by a string inside a bottle having a salt solution with an excess of the salt at the bottom to keep the humidity of the air in the bottle constant. The bottle was kept at room temperatures. In this way, the time at which the larvae changed to pupae, and the length of the pupal stage, were noted, as well as the length of time it took for the young adults to attain their natural color.
Studies of Parasites.

The cocoons of parasites in the bark were removed and reared to adults in a jar like that used to rear the host.

Records of the Physical Environment.

All temperatures were taken with a mercury thermometer and recorded in degrees Fahrenheit. The bulb of the thermometer was shaded during observations.

Studies of Host Materials.

The American elm (Ulmus americana) was used entirely as host material for all the life history experiments in the field and laboratory, since it was the only host upon which the beetles were found locally. Other species of elm were not available for experimental purposes at the time. Logs of trees other than elms were used in one experiment to determine if the beetles would breed in them also.

Life History and Habits

Host Preference.

An attempt was made to determine if beetles which are bred in elm logs can produce another generation of beetles in basswood (Tilia glabra), a tree which is also reported to be a host of Hylurgopinus rufipes. In the experiment, some beetles were confined on elm, some were confined on basswood, and others
were given their choice between elm and basswood. The results of the experiment are shown in the following table.

<table>
<thead>
<tr>
<th>Jar Number</th>
<th>Type of Wood</th>
<th>Number of Beetles</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Basswood</td>
<td>80</td>
<td>Very few bark punctures. No egg galleries made</td>
</tr>
<tr>
<td>2</td>
<td>Basswood</td>
<td>50</td>
<td>Basswood - very few bark punctures. No egg galleries made.</td>
</tr>
<tr>
<td>3</td>
<td>Elm</td>
<td>80</td>
<td>Numerous bark punctures. Egg galleries made.</td>
</tr>
</tbody>
</table>

It is evident from the table that basswood is unattractive to beetles reared in elm under the conditions of the experiment.

Hibernation.

_Hylurgopinus rufipes_ was observed to pass the winter in both the larval and adult forms in Amherst, Massachusetts. The adults passed the winter in short bark tunnels in the trunks of live trees. Larvae of both the first and second generations passed the winter in trap logs. Of the first generation there were merely a straggling few which had had their development stopped by the cold weather in the Fall before they could become adults and emerge with the rest of their generation. Those of the second generation were quite abundant. The eggs from which they developed were laid in late August and in September (Chart III).
Adult Hibernation. In both 1934 and 1935 the first adults were observed in the bark tunnels in the latter part of September, when a considerable amount of dust similar to fine, mixed brown and white sawdust was noticed in the bark crevices of several American elm trees on the Massachusetts State College campus. The two colors of dust were probably due to the alternate light and dark layers of bark which are found in this species of elm. The beetles were digging tunnels into the bark of apparently healthy elms. The tunnels (Fig. 1) were short and not constructed in any regular pattern such as they dig when making egg galleries (Fig. 2). Moreover, egg galleries, as shown later, are confined to dying and recently killed material. All entrance holes were in the crevices of bark and most of the winter tunnels were in the outer bark, but many were in the inner bark, some scoring the sapwood slightly. The following spring a small brown spot about one-fourth inch in diameter was noticed in the sapwood surrounding the spots where the beetles scored it. By November 5, 1934 most of the beetles had stopped boring for the season. A few, however, showed signs of life when disturbed. From time to time during the winter, the infested trees were examined and live beetles observed in a dormant condition (Chart III). During the coldest weather some required exposure to room temperatures for an hour before they revived.

There were many abandoned tunnels in the bark. Some were filled with sap which repelled the beetles, forcing them to
some of the outer layers of bark have been stripped away from the trunk of this American elm (Ulmus americana) to show the tunnels in which *Hylurgopinus rufipes* Rich. adults were found to spend the winter

One-half natural size
Figure 2

Characteristic egg gallery of *Hylurgopinus rufipes* Eich. beneath the bark of American elm (*Ulmus americana*)

Natural size
withdraw and start tunnels elsewhere. Frequently the abandoned tunnels were occupied by other small forms of animal life. During the latter part of the winter many adults died in their tunnels. Many of these beetles were enveloped in a white fungous growth resembling that so commonly seen on dead bark beetles within their tunnels.

The greatest number of the bark tunnels were on the trunks of the trees near the ground level, several being in the bark of exposed roots. Where a tree forked near the ground, the rougher and thicker bark in the crotches showed a greater infestation than the thinner and smoother bark surfaces on the trunk. The infestation was less abundant toward the upper part of the trunk.

It was interesting to note that the most heavily infested trees were near a log pile containing many elm logs which showed old egg galleries of *H. rufipes* from seasons past. These galleries contained only the dead parent beetles which commonly die in the egg galleries they construct.

The bark tunnels were examined throughout the entire period of adult occupation. Observations were made daily during the period of attack in the Fall and the period of renewed activity in the Spring. During mid-winter, examinations were made only at about three week intervals.

A table showing the sequence of activities in these tunnels follows:
<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sept. 29, 1934</td>
<td>Adults in abundance attacking trunks of live elms.</td>
<td>70</td>
</tr>
<tr>
<td>Nov. 5, 1934</td>
<td>Most of the adults in the tunnels had stopped digging for the season.</td>
<td>66</td>
</tr>
<tr>
<td>Dec. 15, 1934</td>
<td>All beetles in tunnels now dormant. No signs of life when disturbed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Required one hour of exposure to room temperatures to revive.</td>
<td></td>
</tr>
<tr>
<td>Jan. 18, 1935</td>
<td>Still dormant.</td>
<td>34</td>
</tr>
<tr>
<td>March 16, 1935</td>
<td>A few beetles showed signs of life when disturbed.</td>
<td>68</td>
</tr>
<tr>
<td>April 19, 1935</td>
<td>First boring dust found in crevices of the bark, showing that beetles renewed digging in their tunnels.</td>
<td>64</td>
</tr>
<tr>
<td>April 27, 1935</td>
<td>Beetles actively digging in tunnels. Boring dust very abundant in crevices of bark.</td>
<td>86</td>
</tr>
<tr>
<td>May 11, 1935</td>
<td>First beetles crawling about on the bark.</td>
<td>65</td>
</tr>
<tr>
<td>May 13, 1935</td>
<td>First adults observed flying and landing on tree trunks.</td>
<td>73</td>
</tr>
<tr>
<td>May 20, 1935</td>
<td>Egg galleries started in elm logs which were exposed to attract the beetles.</td>
<td>68</td>
</tr>
</tbody>
</table>

* All temperatures were taken from the Massachusetts State College Experiment Station weather reports.
The relationships between the beetles' activities and the air temperatures during the spring period of flight were observed to be as follows:

- Flying ......................... 66 degrees Fahr. and above
- Crawling on bark only .......... 60 degrees Fahr. and above
- Digging in tunnels only ........ 55 degrees Fahr. and above

At no time were egg galleries seen in the bark of healthy trees, as were the winter tunnels. As the egg galleries became more numerous in the trap logs in the spring, fewer beetles were found in the bark tunnels in the living trees.

**Larval Hibernation.** Hibernating larvae were not seen until the second winter (1935-36) when only fifteen almost mature larvae of the first generation were found in logs in one of the field jars. Five young live adults were found at the ends of larval galleries from which they had not yet emerged. These larvae and adults belonged to the same generation as the beetles which had already emerged. The cold weather had apparently arrested their development and activity. Similar examinations made on other logs placed in the field at the same time in the spring produced similar results. A few of these logs, however, showed that the entire brood had
already emerged. No live pupae were found among the few individuals which were collected in the field during the winter (Chart III).

In August 1936 trap logs were placed in the field. Adults of the first generation which emerged at this time constructed egg galleries in these logs and produced a second generation which over-wintered as larvae (Chart III).

Brood Galleries.

Egg Galleries. The beetles first attacked freshly cut elm logs in the latter part of May (May 20) and started constructing egg tunnels beneath the bark (Chart III). One beetle, presumably the female, would start the hole (Garman, 1899) while another beetle, presumably the male, would take a position directly behind it. When annoyed with a blade of grass, the male would move about as if to protect the female. When the female tunneled below the surface, the male would stand just outside the hole, sometimes partially covering it with his body. Later, when the hole was deep enough, the male entered and remained in the entrance, its elytral declivity effectively blocking the opening against enemies. By carefully cutting away the bark beside the tunnel and covering it with celluloid, some of the activities within could be observed. The female bored directly into the sapwood and then across the grain of the inner bark, slightly scoring the sapwood. The male usually remained near the entrance hole, but sometimes was found in a side niche in the section of the tunnel between the
entrance hole and the sapwood. The male's role seemed to be that of guardian, in that its presence at the entrance hole prevented enemies from attacking the female digging below, and also that of janitor, as it helped remove boring dust pushed back to it by the female. This operation was performed with the tibia and tarsi. The female laid its eggs in the branches of the tunnel which ran across the grain of the inner bark. These eggs were laid singly in tiny niches dug into both sides of each branch of the tunnel as they extended through the tissues of the bark. Each egg was covered with closely-packed boring dust which the female produced as she dug the tunnel.

Subsequent development was not observed until three weeks later when bark was removed from the log and placed between two pieces of glass, as previously described under "Methods and Technique." There were two branches to the egg gallery at that time. Sometimes the female was digging and laying eggs in one branch while the male was still near the entrance hole. At other times the female would be in one branch and the male would be in the other. Many parent beetles remained alive in their galleries until the latter part of July when the first young adults were found at the ends of larval galleries beneath the bark. Some had died previous to this time. In most of the egg galleries observed, only one dead beetle was present after the gallery was completed. This habit is quite characteristic of other species of scolytids. The male usually leaves after the egg gallery is well started.
The completed egg gallery characteristically consists of two branches which extend in opposite directions from the entrance hole across the grain of the inner bark. Under crowded conditions, however, these galleries vary slightly from this shape, because of the beetle's efforts to avoid breaking through to a neighboring tunnel. Some have a "Y" shape, the two branches of which extend in almost any direction in relation to the grain of the bark. None has been found, however, with both branches parallel to the grain. Sometimes an egg gallery will have only one branch extending more or less across the grain with but a vestige of a second branch in which there are no eggs. The total lengths of the egg galleries varied from about 1.5 cm. to 6.0 cm. They were about 1.5 mm. wide.

Larval Galleries. The larvae which hatch from the eggs begin digging away from the parent egg gallery at approximately right angles. Those larvae which hatch first from the earlier-laid eggs and the faster digging larvae continue to extend their tunnels at this angle. As the larvae grow, the galleries widen and force the later-developing larvae to bear away from their neighbors which started digging sooner, until those larvae developing from the last laid eggs will curve their galleries so that finally they are digging in the same direction as their parent egg gallery, unless they are cut off entirely from further development by neighboring galleries.
The young larvae usually burrow in the inner bark next to the sapwood, and are exposed when the bark is removed. The older larvae often leave the cambial region and dig wholly within the inner bark and are therefore not exposed to view when the bark is torn off. However, a few may remain next to the sapwood.

On July 12 the first pupae were found (Chart III). Pupation takes place at the ends of the galleries. The pupation period usually lasted from six to eight days, in the experiments. The newly transformed adults are a very pale tan in color, almost the same shade as the larvae. They soon become darker, bore outward through the bark, and emerge through holes about one mm. in diameter. Some bore aimlessly about in the inner bark before emerging. A few of these latter perish without emerging.

### Adult Emergence

Immediately preceding the emergence period several logs between 4 and 9 inches in diameter and cut to 20 inches in length were placed in six glass cylinders placed in a horizontal position. These logs were taken from two infested log piles. One pile (No. 1) was located in a cool, shady gully beside a stream; the other pile (No. 2) was at the top of the gully near a field where the daily temperature was from one to three degrees Fahrenheit higher on sunny days. Each pile consisted of three layers of logs piled on the ground. The
CHART I

EMERGENCE RECORD of
HYLURGOFINUS RUFIPES.

A Moving Average Graph Using
Three Day Periods

Log Pile # 1

Number of Beetles Emerged

August 1935  September  October
CHART II

EMERGENCE RECORD
of
HYLURGOPINUS RUFIPES

A Moving Average Graph
Using
Three Day Periods

Log Pile # 2

Number of Beetles Emerged

July 23 - August 31
August
September 1835
October
individual logs were about four feet long and were between
four and nine inches in diameter. The log piles were about
five feet long.

The ends of the glass cylinders in which the logs were
placed were covered with voile. One cylinder contained wood
from the top log in one pile; a second contained wood from
the bottom of the pile; the third contained sections of each
log in the pile. The other three cylinders were similarly
prepared with wood from the second pile.

Adult emergence began July 30th from both the log pile
and the logs in the cylinders in the warmer location, and ten
days later from those in the cooler location (Chart III).
After emergence was under way in both piles, the daily fluct-
uations in the amount of emergence in the two locations was
almost identical throughout the season. However, the greatest
emergence from the log pile in the warmer location was attained
on August 20th, while maximum emergence from the log pile in
the cooler location was attained on September 11th. Charts
I and II show the daily emergence from sections of all logs in
both log piles based on a moving average curve using three day
periods.

Beatles emerged from the logs taken from the tops of the
piles a few days earlier than from the logs taken from the
bottom, but the total number produced in the lowest logs was
larger than in the top logs of the same size. This is shown
in the following table:
Activities after Emergence.

In the field, the adult beetles were not observed to attack twigs for feeding purposes, as reported by Britton (1935). They did, however, when confined with twigs in cages. Soon after a heavy emergence of Hylurgopinus rufipes from elm logs in Amherst and in Westfield, Massachusetts, the beetles were seen digging short bark tunnels into the trunks of apparently healthy American elm trees. These tunnels are of the same type as those in which they spend the winter. In Westfield, the attack was noticed during the second week in August. In Amherst, this attack was not noticed until the following year (1936) near the end of August (Chart III). A close examination of several trees showed the presence of short bark tunnels in trunks and branches even in the upper parts of the trees. The crotches of some small branches, approximately one inch in diameter and over, showed the presence of bark tunnels. In the smaller branches, however, there were decidedly fewer tunnels per unit of area than in the trunk near the ground level. No case of twig feeding was found, even where twigs lay against a part of the trunk which showed numerous bark
tunnels. This habit seems to differ slightly from that of the young adults of *Scolytus multistriatus* which are reported to attack small elm twigs and buds. Only when *Hylurgopinus rufipes* adults were confined on small elm twigs in the field and laboratory did they attack them. Whenever they had a choice between small twigs and stouter elm material, they did not attack the twigs.

At about the time the bark tunnels were noticed in the trees in Amherst, egg galleries were constructed in nearby trap logs, and a second generation started which is wintering in the larval stage (Chart III). Numerous bark tunnels were also in the trap logs.

In the Fall of 1934, 1935, and 1936 the trunks of elms were attacked by *Hylurgopinus rufipes* adults. Repeated examinations during these winters showed the presence of live adults in tunnels in the bark of these trees.

A summary of the complete activities of *Hylurgopinus rufipes* as described in the previous pages of this section on "Life History and Habits" is shown in graphic form in Chart III.
FIELD ACTIVITIES of HYLURGOPINUS RUFIPES at Amherst, Mass. 1934-1936

Legend
- Form Abundant
- Form Scarc / Larval Period - First Generation
- 1st Generation
- 2nd Generation
- Last Date Hypothetical

CHART III

- Larval Period - Second generation
- Egg galleries constructed after a second generation
- Young adults emerge
- Young Adults present in larval galleries - First generation
- Pupal Period - First Generation
- Adults resume digging in bark tunnels
- Adults overwinter in bark tunnels
- Larval Period - First Generation
- Egg galleries constructed
- Parents adults die in egg galleries
- Many adults overwinter in bark tunnels

Reproductive Potential

Although the egg galleries are two-branched, the species is reported to be monogamous (Swains, 1913). No readily visible method of differentiating the sexes was known when this work was done, but my observations tended to bear out his findings. When bark was stripped from logs, never more than two beetles were found in a gallery, one of which was near the entrance hole, the other in one of the branches. Sometimes one would be in each branch. In many, only one adult was found, the second being absent, as often is the case with male bark beetles. In the Spring of 1935 I carefully transferred the two adults from each of four newly-started egg galleries in the field to a caged log in the laboratory. Four egg galleries were made, each with the characteristic forked tunnel. The behavior of the individuals in a gallery was characteristic of the behavior of the male and female of other monogamous scolytids. Only one dead parent beetle remained in each gallery when it was completed.

The number of eggs found in a series of egg galleries which were examined varied considerably. In a few galleries both parents died before any eggs were laid. In some galleries both parents died after only six or eight eggs were laid. Finding between twenty and eighty eggs to a gallery was quite common. The maximum number of eggs found in one egg gallery was one hundred and twenty-four. McDaniel (1935) reports that a female lays from twenty to seventy-five eggs in a brood tunnel.
A table comparing the number of egg galleries with the total number of first generation adults which emerged, follows. This table also shows the average number of progeny produced from one egg gallery.

<table>
<thead>
<tr>
<th>Total Adult Emergence</th>
<th>Number of Egg Galleries</th>
<th>Average Number of Adults Emerged per Gallery</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,132</td>
<td>172</td>
<td>12.39</td>
</tr>
<tr>
<td>1,947</td>
<td>119</td>
<td>16.36</td>
</tr>
<tr>
<td>Total 4,079</td>
<td>291</td>
<td>14.017</td>
</tr>
</tbody>
</table>

Since an average of only fourteen individuals were secured from 291 galleries, there would seem to be a heavy mortality among the immature stages. This may have been due to the crowded condition of the larvae in the logs under observation. The faster-growing larvae crowd out the slower, and thus prevent their further growth in many cases. Parasites and possibly predators might take their toll, and the physical environment must also cause some mortality.

Associated Arthropods

Several kinds of insects and other Arthropods are associated with the various life stages of *Hylurgopinus rufipes*, or with the galleries in which they live. Below is a list of these Arthropods, supplemented by a short account of the activities observed.
INSECTA

Collembola.

These were on the trunks of elm, in the winter galleries and in the egg galleries in the field, and were numerous in the rearing jars. A list of the species follows:

- Orchesella cincta L.
- Isotoma cinerea Nic.
- Tomocerus vulgaris Tull.
- Sira buski Lubb.

Coleoptera.

The galleries of a few other wood-boring insects were often intermingled with those of H. rufipes. These included:

- Scolytus multistriatus Marsh.
- Magdalis spp.
- Saperda tridentata Oliv.

Saperda tridentata was most commonly found in samples collected from all parts of the state. They attack elm bark about the same time as Hylurgopinus rufipes but require until the following spring to emerge as adults, whereas practically all of the American bark beetles on elm emerge the same season that development started, if the eggs from which they developed were laid in the spring. The galleries of Saperda tridentata are long, winding and broad, and practically obliterated the gallery patterns of Hylurgopinus rufipes by the end of the first summer.
A small beetle, *Platysoma coarctatum* Lec., was found in abandoned winter tunnels of *Hylurgopinus rufipes*.

Two beetles were attracted to the sap which flowed from a tunnel made by *Hylurgopinus rufipes* in the trunk of a healthy tree during the early spring. They were:

- *Euphoria inda* L.  Scarabaeidae
- *Glischrochilus fasciatus* Oliv.  Mitulidae

A. D. Hopkins (1893) reports that a Clerid beetle, *Thanasimus dubius*, is predaceous on *Hylurgopinus rufipes*.

**Diptera.**

Tiny undetermined dipterous larvae were occasionally found in the egg galleries.

**Hymenoptera.**

A tiny cocoon of a Hymenopterous insect was occasionally found at the end of an unfinished larval gallery. A dried larval skin of *Hylurgopinus rufipes* was always attached to the cocoon, suggesting parasitism or predatism. Doctor Husebeck of the United States National Museum identified the species as *Spathius canadensis* Ashmead, family Braconidae. It is an insect recorded as a parasite of several species of bark beetles and weevils, including *Phloeosinus dentatus* Say, *Ips grandicollis* Fich. (Leonard, 1926); *Dryocoetes americanus* Hopk., *Tomicus cacographus*, *Phloeosinus graniger* Chap. (Pierce, 1908); *Scolytus rugulosus* Ratz. (Schedl, 1932); and *Magdalis olyra* Hbst. (Pierce, 1908).
ARACHNIDA

Aranida.

Several tiny undetermined species of spiders were found in abandoned winter tunnels. Some spider eggs were found in the egg and larval galleries of Hylurgopinus rufipes. Acarina.

Mites were numerous in egg and larval galleries. When sections of beetle-infested bark were examined microscopically they were readily seen crawling about in the tunnels. An undetermined species of mite was seen on the bodies of adult beetles, apparently doing no harm.
Hibernating Habits

In the vicinity of Amherst, Massachusetts, young *Hylurgopinus rufipes* adults of the first generation may pass the winter in short tunnels which they dig in the bark of apparently healthy elms. Sometimes the sapwood is slightly scored. A very small percentage of almost mature larvae and also some young adults of this same generation may overwinter in larval galleries in the logs in which they develop.

Spring and Summer Activity

The young adults which had passed the winter in the overwintering tunnels resumed digging in them the third week in April. They left these tunnels and began constructing egg galleries in elm logs near the end of May. These beetles remained alive in their egg galleries until the middle of July. Either one or both parents die in the egg gallery they construct.

The young larvae which hatch from the eggs laid by the parent female in niches along the side of the egg gallery, dig away from the parent egg gallery through the inner bark and pupate at the ends of the galleries they construct. The galleries the larvae construct are known as larval galleries. When the pupae become adults, they dig out to the surface of the bark and emerge from their galleries. Each beetle leaves a tiny hole about one millimeter in diameter.
Adult emergence begins about the end of July and continues until past the middle of October, most emergence taking place during August and September. A few individuals of the same generation may pass the winter in the larval stage. Young adult beetles were not observed to feed upon elm twigs in nature, as reported by Britton (1935). They were found, however, to dig short bark tunnels into the trunks and branches of apparently healthy elms in August soon after a heavy emergence from nearby elm logs. The small twigs were not touched in nature. A second generation started at about this same time, passing the winter in the larval stage.

Host Preference

American elm (Ulmus americana) was the only species of elm available for experimental purposes at the time this work was done. The beetles were successful in rearing a new generation in it whenever it was exposed to their attack. Basswood (Tilia glabra) was not chosen for breeding purposes by adults which were reared in elm. Various authors cite it as being a host of the beetle.

Reproductive Potential

Although it is common for the beetles to lay between twenty and eighty eggs, and as high as one hundred twenty-four, the average number of beetles reaching the adult stage was only fourteen per egg gallery, in the experiments.
Associated Arthropods

Spatnus canadensis Ashmead, a Braconid, which is reported to be a parasite of several species of bark beetles and weevils, was found to parasitize Hylurgopinus rufipes also. Several insects, spiders and mites were associated with the beetles themselves, or with the galleries they make.

The Habits of Hylurgopinus rufipes and Scolytus multistriatus Compared

The boring habits of Hylurgopinus rufipes are similar to those of Scolytus multistriatus Marsh., the only other elm bark beetle present in abundance in this country. Scolytus multistriatus is today considered to be the most important vector of the Dutch elm disease in America. Because of this fact, Hylurgopinus rufipes should also be regarded with suspicion in this respect. Since this problem was started, several authors have found, through experiments, that Hylurgopinus rufipes is capable of spreading Ceratostomella ulmi, the causal organism of the Dutch elm disease (Collins, Buchanan, Whitten, and Hoffmann, 1936; Britton, 1935; Clinton and McCormick, 1935).
CONCLUSIONS

1. There is one complete generation and a partial second generation in a single season in the vicinity of Amherst, Massachusetts.

2. *Hylurgopinus rufipes* breeds in the bark of recently killed elm wood. The adults later dig tunnels in the bark of thrifty elms, sometimes scoring the sapwood slightly. They may go directly to the bark of recently killed elm wood to start another generation of beetles, or they may spend the winter in the tunnel in the bark of the healthy tree. This life cycle is very similar to that of *Scolytus multistriatus* Marsh.

3. The beetles which are bred in elm will not breed in basswood, which is also reported to be a host of *Hylurgopinus rufipes*. 
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ACKNOWLEDGEMENTS

Sincere thanks are due to Professor H. L. Sweetman for his helpful suggestions and his constructive criticism of the manuscript. Professors A. V. Osmun and L. L. Blundell offered useful advice in the composition of the thesis. The Massachusetts Agricultural Experiment Station kindly permitted the use of photographs. The author is also indebted to the late Doctor Justus W. Folsom for identification of Collembola, and to Mr. C. A. Frost for identification of Coleoptera.
Approved By

Harvey L. Sweetman

Alvernet Onder

L. L. Blumell

Thesis Committee

May 1937