Characteristics of structures attacked by the wood-infesting beetle, *Hemicoelus gibbicollis* (Coleoptera: Anobiidae)

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ABSTRACT

The anobiid, *Hemicoelus gibbicollis* (LeConte), is the most serious structure-infesting beetle along the Pacific Coast. This species attacks damp timbers (13-19% moisture content) in crawl spaces, basements, and outbuildings. In structures monitored for anobiids, Douglas-fir, *Pseudotsuga menziesii* (Mirbel), was the most abundant and readily attacked wood species, but other timbers used in building construction were also infested. Sapwood is more seriously infested than heartwood, and wood of any age can be attacked. Sill plates, rim joists, and headers adjacent to concrete foundations are among the most seriously damaged timbers. Infested buildings ranged from 8 to 122 years old, $\bar{x}$ = 63.2. Infestations persist for many years. New, air-tight houses built with an abundance of sapwood in construction timbers may be at risk of beetle attack unless moisture levels are kept at a minimum.

INTRODUCTION

Infestations attributed to powderpost beetles have been reported from structures along the Pacific Coast of western North America for more than 50 years (Doane et al. 1936, Hatch 1946, Chamberlin 1949). Examinations of infested timbers showed that deathwatch beetles (Coleoptera: Anobiidae) were responsible for most of the damage. Larval feeding over a period of years often resulted in a weakened structure, necessitating replacement of timbers. The anobiid, *Hemicoelus* (=*Hadrobregmus*) *gibbicollis* (LeConte), was ultimately implicated as the primary pest species (Linsley 1943). Despite the seriousness of numerous infestations, the biology of this beetle remained incompletely recorded for many years (Furniss and Carolin 1977).

Although lacking adequate biological information, pest control operators (PCOs) routinely apply insecticides as structural treatments for anobiids. Evaluation of beetle activity within timbers is extremely difficult and many buildings are still being treated for inactive infestations. Most PCOs rely on the presence of adult exit holes as their main indication of anobiid activity, but this has been shown to be unreliable (Suomi 1992). Williams et al. (1979) stated that the number of exit holes does not necessarily indicate the activity of an infestation; only the existence of larvae does. Radiography is the most reliable method for determining numbers of larvae present within wood but it is impractical for field use. The presence of larval frass expelled from adult beetle emergence holes can be used as an indicator of activity. Frass the color of freshly produced sawdust often reveals on-going larval feeding within timbers.

Hemicoelus gibbicollis is found primarily in damp timbers of crawl spaces, basements, barns, and outbuildings in humid coastal areas of western North America. Analyses of museum collections from western states and surveys conducted in Washington and Oregon have failed to identify this species from dry, inland areas (Suomi 1992).

MATERIALS AND METHODS

Data Collection From Infested Structures.

During 1987-91 PCOs, extension specialists and county agents, and homeowners contacted us with information on houses or outbuildings with possible anobiid beetle infestations. From >120 potential sites, we selected 90 structures (3 log houses, 11 outbuildings, and 76 frame houses; 9 with a basement and 67 with a crawl space) in western Washington and Oregon which were infested with *H. gibbicollis*. Buildings with inaccessible infestations, those having been chemically treated, or structures with unknown histories were excluded. A survey form (Suomi 1992: appendix 6) was developed to record site conditions. Efforts were made to collect all available historical data from each building owner.

In all cases, damaged timbers were collected for positive identification of the infesting insect species. Wood moisture content readings were taken with a Delmhorst Model RC-1C Moisture Meter (Delmhorst Instrument Company, Boonton, New Jersey) or a Mini-Super Wood Moisture Meter (Protimeter, Meter House, Marlow, Bucks, England). Efforts were made to take readings from sound and infested wood to check for differences. Temperature and relative humidity (RH) readings were recorded with a Hanna Thermohygrometer Model HI 8564 (Cole-Parmer Instrument Company, Chicago, Illinois). All readings were taken from five locations within the structure and mean values determined.

Simulated Crawl spaces.

In Pullman (eastern Washington) and Puyallup (western Washington), two simulated crawl spaces were made from 39.4 × 19.1 × 19.1 cm concrete foundation blocks. Each structure was located near buildings with crawl spaces, but away from areas that could be disturbed by humans. Interior dimensions of the simulated crawl spaces measured 161.3 × 41.9 × 58.4 cm. A peaked roof was constructed from 1.9 cm (3/4") plywood, covered with tar paper to allow water runoff, and mounted on hinges. The structure was partitioned into three separate compartments with 1.9 cm plywood (Fig. 1). The first compartment had a soil substrate and no ventilation, other than air entering between the wood/block interface; the second had no additional ventilation, but a 6 mil vapor barrier was used to cover the substrate; and the third compartment had a 6 mil vapor barrier and one vent (30.5 × 11.4 cm) which was covered by a metal screen (0.24 cm^2 openings). Temperature and RH within each compartment were registered on a Jumbo Dial (Thermometer Corporation of America, Springfield, Ohio) and recorded every two weeks for 18 months in Pullman and Puyallup. In addition, readings of wood moisture content were taken from two wood blocks kept in each of the three separate compartments for 18 months, at the Pullman site only.

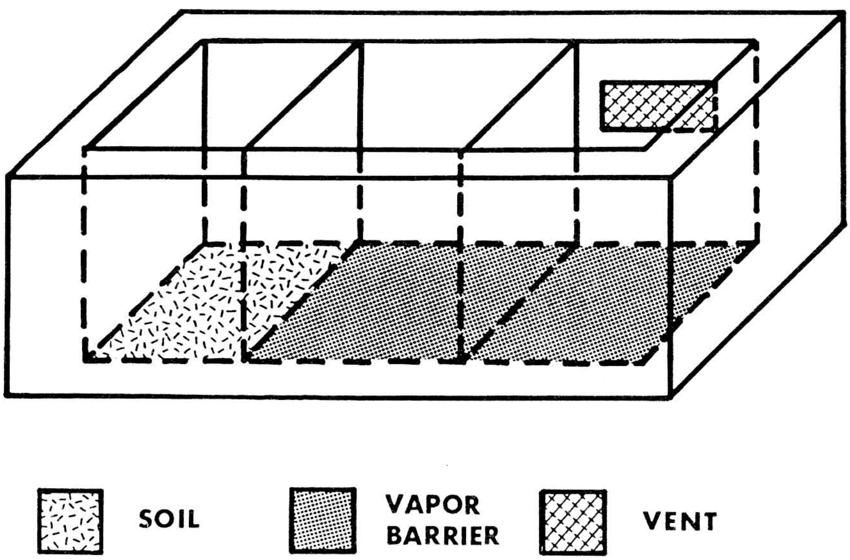

Figure 1. Simulated crawl space design for monitoring temperature and relative humidity. The compartments were of equal size.

Table 1
Wood moisture levels in structures[1] infested with *Hemicoelus gibbicollis*.

Wood moisture content (%)	No. of structures	% of structures
12	1	1.6
13	11	17.2
14	8	12.5
15	12	18.7
16	11	17.2
17	15	23.4
18	4	6.2
19	1	1.6
21	1	1.6

[1]total of 64 structures, wood moisture meters unavailable during 1987 field season.

RESULTS AND DISCUSSION

Natural Infestations.

Hemicoelus gibbicollis is primarily an economic concern in houses with crawl spaces or damp basements, but will infest any suitable structural timbers. Williams and Smythe (1978) reported that >99% of 673 beetle (primarily anobiid) infestations in Arkansas were located in crawl spaces beneath houses. The most susceptible wood for a natural anobiid infestation is sapwood from dead standing trees or stumps that remains undecayed for at least 3 years, because most wood-infesting anobiids have a 3 year life cycle in nature (Berry 1976). Sapwood in contact with the ground will be totally decayed by wood-destroying microorganisms in 3 years or less (Shigo 1968), so anobiids are often unable to complete development in this decomposing wood.

During these investigations we observed six structures that were probably infested from stumps left in the crawl space area. Wooden debris, in contact with the substrate, that remained after construction was completed could also serve as the initial infestation site. Undecayed stumps, plywood form boards, and even wooden tools often were seriously infested. The beetles would then move into the substructure.

Wood Moisture.

Probably the most important factor that allows these beetles to survive and reproduce is wood with a moisture content between 13 and 19% (Table 1). Levels above 19% led to development of molds or other microorganisms which effectively reduce the numbers of eggs and larvae. On two occasions, larvae were found in wall studs on shaded sides of homes (usually north) when the wood moisture content was >19% within the substructure. Wood with moisture content levels below 12% resulted in reduced larval populations (Suomi 1992). Areas of homes normally exposed to sunlight may dry out enough to reduce or prevent anobiid survival. Generally, the moisture content of wood in eastern Washington structures remains below 12%, which prevents *H. gibbicollis* from infesting structural timbers east of the Cascade Mountains. Relative humidity and therefore wood moisture content within the vapor barrier and vented compartments of mock crawl spaces in both eastern (Fig. 2a) and western Washington (Fig. 2b) remained significantly lower than the portion with only a vapor barrier or no treatment (Table 2). However, these values were considerably higher than are typically found in eastern Washington because the simulated crawl space was in a poorly drained location. Wood moisture content readings were approximately 2% less in simulated crawl space compartments with ventilation or a vapor barrier or both (Table 3).

Hosts.

In nature, *H. gibbicollis* larvae attack a wide variety of softwoods and hardwoods (Knutson 1963). Douglas-fir, *Pseudotsuga menziesii* (Mirbel), was the primary structural timber species infested (97.8%), due in large part to its widespread use in building construction. Western red cedar, *Thuja plicata* Don, and western hemlock, *Tsuga heterophylla* (Rafinesque) were attacked in about 2% of the structures examined.

Table 2

Temperature and relative humidity data from simulated crawl spaces in eastern and western Washington.

Treatment	Temp. range (°C)	$\bar{x} \pm$ SEM	RH range (%)	$\bar{x} \pm$ SEM
Western Washington				
VB + V[1]	−4.0 - 25.5	11.7 ± 1.2	27 - 42	34.1 ± 0.7[a]
VB	−5.5 - 25.5	10.4 ± 1.3	30 - 41	37.1 ± 0.5[a]
NONE	−4.5 - 24.0	9.9 ± 1.1	31 - 44	37.9 ± 0.6[b]
Eastern Washington				
VB + V	−4.5 - 20.5	7.8 ± 1.1	37 - 50	45.1 ± 0.4[a]
VB	−4.0 - 21.0	7.8 ± 0.7	37 - 54	46.3 ± 0.5[a]
NONE	−3.5 - 20.0	7.7 ± 0.7	38 - 56	50.5 ± 0.5[b]

Means (RH) followed by the same letter do not differ significantly ($P = 0.05$) based on t tests (SAS Institute 1985).

[1]V = vent; VB = vapor barrier; NONE = neither treatment.

Authorities (Linsley 1943, Chamberlin 1949, Ebeling 1975, Hickin 1981, Mampe 1982) have stated that anobiid beetles will only attack wood that is well seasoned or has been in service at least 20 years. This is not always the case with *H. gibbicollis* (Table 4). Exit holes produced by emerging adult beetles may not become immediately obvious because the insect can spend up to six years as a larva (Suomi 1992). Moreover, the inaccessible nature of many infestations often prevents their discovery for 20 years or more.

New timbers, cut from trees containing increased sapwood grown in short rotation forests, can become seriously infested in only a few years. We have seen at least seven structures that showed signs of larval activity and adult emergence in replacement timbers that were present for <7 years. Infested buildings ranged from 8 to 122 years old, with an average age of 63.2 years. Williams and Smythe (1978) determined that anobiid-infested houses in Georgia and Mississippi ranged from 9 to >100 years old, with an average age of about 37 years.

Williams and Barnes (1979) have ascertained that well designed floor systems should adequately compensate for any weakening caused by the anobiid, *Euvrilletta peltata* (Harris) [=*Xyletinus pelatus* (Harris)]. Within structural timbers, numbers of *H. gibbicollis* larvae are often much greater (Suomi 1992) and therefore weakened timbers should be promptly replaced. Several PCOs in the Pacific Northwest have unwisely recommended placing an untreated floor joist between infested joists to strengthen the floor and avoid chemical treatment of the structure. Because of the potential for rapid anobiid attacks on these timbers, this practice must be discouraged.

Infestation Sites.

Hemicoelus gibbicollis adults are poor fliers, so many infestations may be established by beetles that walk to the structure (Suomi 1992). Natural openings such as crawl space entrances or vents usually serve as initial infestation sites. Sill plates, rim joists, and headers adjacent to concrete foundations are among the most seriously damaged timbers. As an infestation progresses, any area within the substructure can be attacked.

The outer edges of floor and rim joists were often seriously tunneled, while the interior of these timbers remained uninfested. This condition results from a high proportion of heartwood being found in construction lumber used in houses built earlier in this century. Heartwood contains extractives that repel many insects (Miller 1987) so *H. gibbicollis* larvae were usually found within the sapwood portion of timbers. In certain instances, larvae would tunnel in heartwood, generally when the sapwood had been depleted. Two other wood-infesting anobiids, *Anobium punctatum* (De Geer) and *E. peltata*, are also predominantly found in sapwood because it is higher in carbohydrates and nitrogen (Becker 1942, Bletchly and Farmer 1959, Williams and Mauldin 1981).

Characteristics of Infested Structures.

Many houses are now built with central heating and air conditioning units which lower the RH and wood moisture content below the threshold necessary for anobiid survival. However, the air-tight conditions found in some new buildings can also lead to wood moisture levels that encourage beetle attack. Relative humidity levels within western Washington substructures ranged from 47 to 95%, the average value being 69.7%. Clothes dryers vented into crawl spaces increased RH within the enclosed area and plumbing leaks may also lead to moisture-related insect problems. Improper placement of vents, inadequate ventilation, or obstructed air flow caused by excessive vegetation or debris can produce high wood moisture content, even in well built houses. In this study only 40% of houses had adequate vents (0.09 m^2 vent surface:13.80 m^2 crawl space area, minimally required) and 55% of those houses had vents which were obstructed in some way. Dead air spaces, resulting from little or no air movement within substructures, often result in areas of high wood moisture content.

Table 3

Wood moisture data from eastern Washington simulated crawl space.

Treatment	Wood moisture range (%)	$\bar{x} \pm$ SEM
VB + V1	10 - 19	15.2 ± 0.4[a]
VB	8 - 18	14.9 ± 0.4[a]
NONE	10 - 22	17.2 ± 0.4[b]

Means followed by the same letter do not differ significantly ($P = 0.05$) based on t tests (SAS Institute 1985).

1 V = vent; VB = vapor barrier; NONE = neither treatment.

Table 4

Construction dates of structures[1] infested with *Hemicoelus gibbicollis*.

Date structure built	No. of structures	% of structures
pre-1900	5	6.3
1900-19	24	30.4
1920-39	27	34.2
1940-59	16	20.3
1960-79	5	6.3
after 1979	2	2.5

[1]total of 79 structures, data unavailable for remaining 11 buildings.

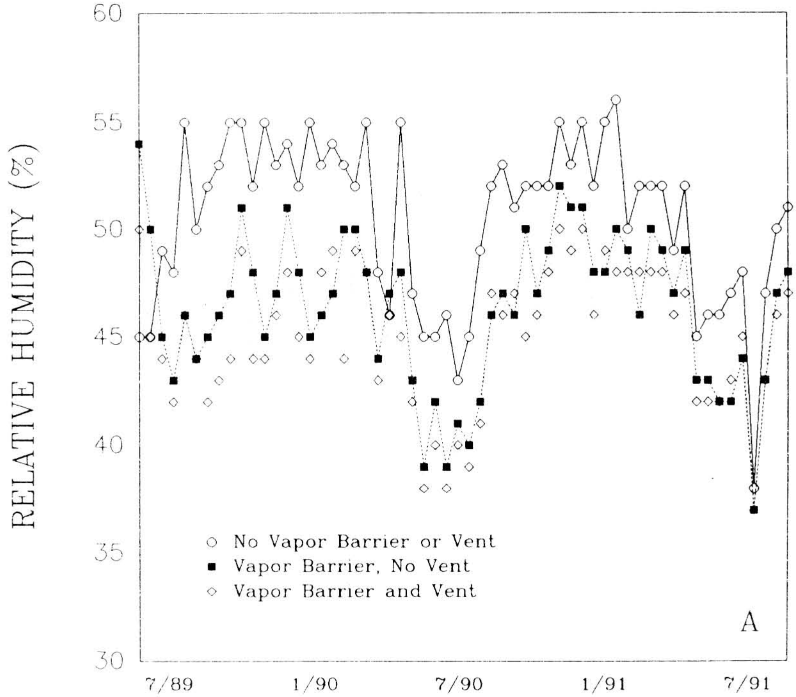

Figure 2a. Relative humidity in simulated crawl space with three partitioned compartments; eastern Washington.

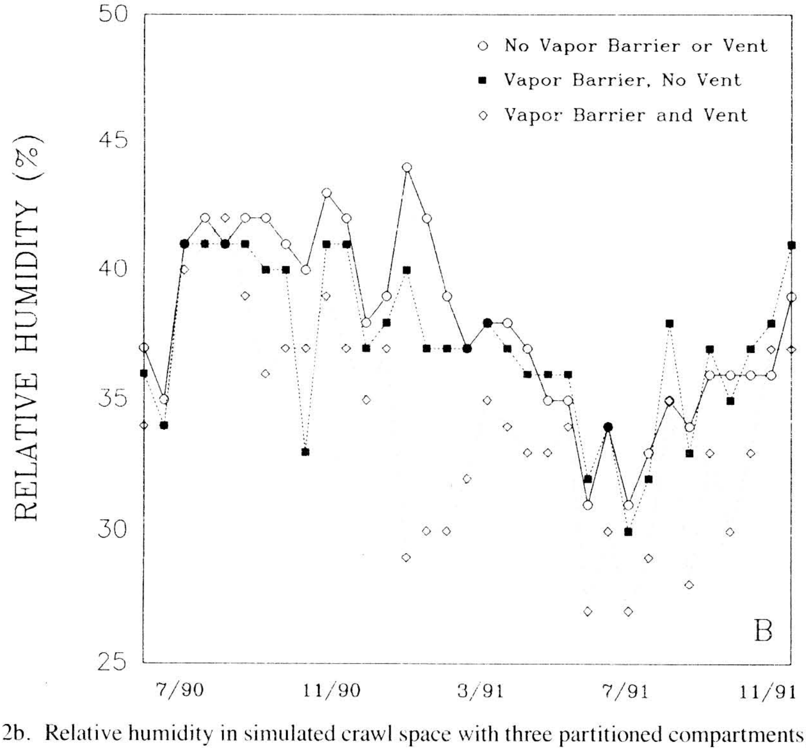

Figure 2b. Relative humidity in simulated crawl space with three partitioned compartments; western Washington.

Excessive wood moisture can be dependent on conditions created outside of the substructure. Contact between wood and soil was common in many houses. Moss or other organic debris on the roof often leads to improper water runoff. Non-functioning gutters may direct water into the crawl space or basement, thus increasing wood moisture content. Improper soil grade is a major contributor to increased water being found in lower levels of buildings. Greater than half of the structures in this study had inadequate gutters or soil grade which resulted in standing water in the substructure.

Barns and outbuildings are often seriously infested by *H. gibbicollis*. These unheated structures present ideal conditions for larval development. Often these outbuildings are continually reinfested until nothing remains but frass and a thin shell of wood. They can then serve as a source of infestation for other main structures. One house was examined that had an unheated, open attic area where conditions were similar to those in a barn. *Hemicoelus gibbicollis* was very active in this structure, infesting not only the ceiling and floor, but also maple and oak furniture stored in the attic. No larval activity was noted in the second floor area beneath the attic, most likely because the wood moisture content was 11-12%. In coastal areas of western Norway, Knudsen (1968) found that *A. punctatum* infested attics and crawl spaces equally.

Wood moisture content, being influenced by RH, is probably the major factor allowing anobiid infestations to develop. Structures located close to bodies of water often had higher than usual wood moisture content and more extensive damage (Suomi, unpublished observations). Clay and other heavy soils that retain water may also contribute to increased wood moisture within a substructure, especially if these soils are not covered with a vapor barrier. Temperature has a limited effect because it influences the amount of moisture remaining in air surrounding wooden timbers (Miller 1987). The average temperature during summer months in western Washington crawl spaces examined in this study was 16.6°C and ranged from 10 to 22°C. *Hemicoelus gibbicollis* is normally found in mild climates where temperature extremes are encountered infrequently. Photoperiod does not appear to have any role in the development of this insect because relatively low, unchanging light levels are normally found within timbers in most crawl spaces. Suomi (1992) showed that *H. gibbicollis* larvae remained active and continued feeding throughout the year, thus demonstrating that time of season does not influence larval activity.

Populations of anobiid larvae present in structural timbers can be reduced, and eventually eliminated, by controlling wood moisture content. One inexpensive method is to cover the entire crawl space floor with a 4-6 mil vapor barrier. Wooden debris and any construction lumber unnecessary to structural support should be removed. Adequate, unobstructed ventilation must be provided for free air movement. Buildings located near the ocean, despite all necessary precautions having been taken, were still found to have wood moisture levels of 14-15% and so remained at risk from beetle infestations. Knudsen (1968) noted that frequency of attacks by *A. punctatum* decreased as distances from coastal areas increased. This was also found to be true of *H. gibbicollis*.

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