luminance. It would seem that there is not a single function, but more probably a family of functions with maintenance luminance as the parameter. Thus studies of light-controlled behavior which use rats from environments of unspecified luminance will not bear comparison with one another; and animals housed in a laboratory between test sessions are not just "stored," but are receiving a treatment (*7*).

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4. All luminance measures are from a Macbeth test plate on the floor of the cage.
5. The probability values after statements were derived by analysis of variance, except the last two, which resulted from *t*-tests.
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Vertical Extension of Mid-Continent Leonardian Insect Occurrences

Abstract. Two new Permian insect-bearing beds are reported. To date, these are geologically the oldest and youngest found in the Wellington formation of Kansas and Oklahoma. Altogether, six such beds are now known. When these beds are stratigraphically placed in relative elevation above the marine Herington limestone, they are found to recur at intervals of approximately 100 feet.

Prior to the present field study, two insect-bearing beds were known from the Wellington formation: the Midco (*1*) and Carlton (*2*). The first indication that other insect-bearing beds were present in this formation came from the discovery of a traceable conchostracan-insect horizon in Marion, Harvey, and Sedgwick counties, Kansas (*3, 4*). Subsequently, a fourth traceable insect-bearing bed was found in Oklahoma and Kansas (*5*). Some of the fauna of the fourth bed has since been described, and the bed has been designated as the *Asthenohymen-Delopterum* bed (*6*).

While searching for the contact of the Milan member (uppermost unit of the Wellington formation) and the next underlying beds, I discovered a fifth insect-bearing bed in Kay County, Oklahoma (locality: Wellington XIX, SE, NW, sec. 20, T29N, R2W). This insect-bearing bed is 30.4 feet above the base of the section, which is at the level of the Chikaskia River. Geologically, it is the youngest Wellington insect-bearing bed found to date.

An exploration to locate contacts between units in the lower 200 feet of the Wellington formation led to the discovery of a sixth, and geologically the oldest presently known, Wellington insect-bearing bed. It was found in Sumner County, Kansas (locality: Wellington XVIII, NW, NE, sec. 23, T34S, R2E). The base of the section at this locality is in a creek floor and the insect-bearing bed is exposed in a road ditch about 19.0 feet above the base.

As previous workers have pointed out (*1, 2*), one must rely on subsurface data to place the insect-bearing beds accurately. The top of the Annelly gypsum is a useful surface datum, although it is spottily exposed or absent from critical localities. The top of the marine Herington limestone is the most satisfactory datum but absence of exposures at critical localities compels one to rely upon subsurface data. Based on subsurface data, Raasch (*1*) placed the Midco beds at 550 feet above the top of the Herington, and Dunbar (*2*) placed the Carlton insect-bearing beds at 250 to 300 feet above the Herington.

The present study establishes that the conchostracan-insect horizon in Marion, Harvey, and Sedgwick counties, Kansas, is about 10.0 feet above the top of the Annelly gypsum. Because the top of the Annelly, as determined in the field, is about 40.0 feet below the Carlton insect-bearing bed, the top of the Annelly must be between 210 and 260 feet above the top of the Herington.

Stratigraphic placement of the two new insect-bearing beds requires a brief explanation. The oldest insect-bearing bed (Wellington XVIII, Sumner County, Kansas—see Table 1, OIB) crops out a little more than 9 miles east of the Kansas Turnpike. Another section in Cowley County, Kansas, 4½ miles east of Wellington XVIII and stratigraphically below it, exposes the basal 50 feet of the Wellington in which no insects were found. At this place, the Wellington rests directly on exposed Herington limestone. Finally, along the Turnpike, a section was found in which the basal gypsiferous shale overlies the top of the Annelly gypsum. Thus, between the Turnpike section and the top of the Herington in the Cowley County section, there is an interval of about 210 feet (derivation of this figure was given in the preceding paragraph). It follows that the Wellington XVIII insect-bearing bed must occur in an interval between 50 and 210 feet above the top of the Herington.

Field relationships (negligible regional dip to west, distances between outcrops) indicate that the insect-bearing bed is closer to the top of the Herington than to the top of the Annelly by a factor of two. This, in turn, permits the estimate that stratigraphically it occurs 50 to 70 feet above the top of the Herington.

The new insect-bearing bed in Kay County, Oklahoma (Wellington XIX, see Table 1, YIB) can be stratigraphically placed by the following line of reasoning: Raasch's Midco bed is 550 feet above the Herington. Some 53 feet of section were measured above this bed in Noble County, Oklahoma. No insects occurred in the upper 45 feet of this section. That can account for 603 feet of the Wellington (that is, 550 feet plus 53 feet). The total thickness of the Wellington is some 700± feet. Thus, the top of the uppermost member of the Wellington, the Milan, must lie 97 feet above the top of the sections measured in Noble County (that is, 700 feet minus 603 feet). However, some 32 feet of section were measured below the top of the Milan limestone (Wellington XI, Sumner County, Kansas) and no insects were found. Accordingly, the Wellington XIX insect-bearing bed appears to occur in the interval 603 to 668 feet above the Herington (that is, 700 feet minus 32 feet).

Another possibility needs consideration. A green copper carbonate stain was noted in a hard, argillaceous limestone some 10 feet above the Wellington XIX insect-bearing bed (copper carbonate stains characterize the Milan member limestones). This suggests that the insect-bearing bed at this locality lies stratigraphically very close to the Milan member. Field observations lend support to this supposition. There are thus two possible interpretations: (i) If the stained limestone is part of the Milan member, then the insect-bearing bed is between 682 and 700 feet above the Herington (that is, thickness of Milan is 8 feet plus 10 feet interval to top of YIB, equals 682 feet); (ii) if it is not part of the Milan member, then

Table 1. Stratigraphic position of Wellington formation insect-bearing beds (Permian, Leonardian, Kansas-Oklahoma). Datum: Top of Herington Limestone. Identification numbers: 6, YIB, youngest insect-bearing bed, Wellington XIX (Tasch, reported herein); 5, A-D, *Asthenohymen-Delopterum* bed (Tasch and Zimmerman, *5*, *6*); 4, Midco (Raasch, *1*); 3, Carlton (Dunbar, *2*); 2, TFB, 10-foot bed—designates the elevation above the top of the Annelly gypsum of this insect-bearing bed (Tasch, *3*, *4*); 1, OIB, oldest insect-bearing bed, Wellington XVIII (Tasch, reported herein).

Identification number	Name of bed	Locality	Elevation above top of marine Herington limestone (feet)	100-foot units above Herington limestone
6	YIB	Kay Co., Okla.	630 to 700	6th
5	A-D	Noble and Kay counties, Okla.; Sumner Co., Kan.	558 to 559	5th
4	Midco*	Noble and Kay counties, Okla.	550±	
3	Carlton†	Dickinson Co., Kan.	250 to 300	3rd to 2nd
2	TFB	Marion, Harvey, and Sedgwick counties, Kan.	220±	
1	OIB	Sumner Co., Kan.	50 to 70	1st

*Midco, three beds in 4.7 feet. †Carlton, three beds in 5.5 feet.

it occupies some portion of the 603-to-608-foot interval. Because of its proximity to the stained limestone noted above, it is inferred that it would be in the upper half of this interval, namely 630 to 668 feet above the Herington. To account for both possibilities, the geologically youngest Wellington insect-bearing bed is assigned to the 630-to-700-foot interval above the Herington.

The stratigraphic position of all known insect-bearing beds in the Wellington is summarized in Table 1.

The first 300 feet above the top of the marine Herington are marked by insect-bearing beds (Table 1, Nos. 1, 2, 3). Data on the fourth 100 feet are lacking, but fossil insects occur in the fifth and sixth 100 feet above the Herington (Table 1, Nos. 4, 5, 6).

In the context of insect-bearing beds occurring at approximately 100-foot intervals, there is also a recurrence at much shorter intervals (1 to 10 feet) as well. Thus, the Carlton bed consists of at least three insect-bearing units in a thickness of 5.5 feet, while in the Noble County Midco bed, there are also three units in a thickness of 4.7 feet. The *Asthenohymen-Delopterum* bed occurs 8 to 9 feet above the Midco bed.

A question may be raised as to the most plausible interpretation of such recurrence. Does it merely indicate recurrence of conditions fortuitous to the preservation of insects as fossils, or can it be taken as suggestive of recurrence of conditions favorable to insect growth and survival? Inspection of Table 1 readily leads to the first interpretation.

The second interpretation, while more difficult to establish conclusively, does have possible merit when the following two factors are considered. First, sections were measured in inches and individual beds were measured in millimeters. Beds were sampled along their entire lateral extent (see *3*, Fig. 4). Hence, the likelihood of bypassing, missing, or failing to locate present insect fossils was considerably diminished. The laboratory procedure of processing large to increasingly smaller chips of rock from all beds in each section strengthens this conclusion. Second, some 89 clam shrimp–bearing beds were discovered in approximately 1000 feet of section (Wellington and overlying Ninnescah shale) and only six insect-bearing beds. Of the latter, five were associated with fossil clam shrimps. Thus, 84 clam shrimp–bearing beds contained no insect fossils. The ecology reconstructed from the lithology and biota (*3*, *4*, *7*) of the 84 clam shrimp–bearing beds is closely similar to that of the five clam shrimp–bearing beds containing insects. If the reported insect occurrences are taken to be mere accidents of preservation in contrast to inimical conditions for preservation at all other times, the near identity of ecological conditions noted above remains to be explained.

Still other evidence should be considered in deciding between the two possible interpretations. (i) No insect-bearing beds were found in the Ninnescah formation which overlies the Wellington, although there were multiple conchostracan occurrences. A conspicuous absence of micro- and macrofloras also characterized the Ninnescah. This last factor may reflect some important environmental change from Wellington time. (ii) The extent to which stratigraphic analysis has now been carried indicates that for two of the insect-bearing beds (see TFB and Carlton, Table 1), ecological conditions prevailed that were strikingly similar in detail [presence of log beds, hopper crystals, similar faunas and lithologies (*4*)]. The intervening 30 feet of section between the two insect-bearing beds lacked one, several, or all of these characteristics in addition to being barren of insect fossils. (iii) Short-term environmental changes arising from alternate wetting and drying cycles were shown elsewhere (*7*, *8*) to be a factor in clam shrimp speciation during Wellington time.

The evidence in the paragraph before the preceding one, and item iii in the preceding paragraph, suggest that insect occurrences and recurrences in the Wellington may be more than mere accidents of preservation and may reflect a cyclic sequence of some kind. Items i and ii in the preceding paragraph may be taken to argue for or against this interpretation (*9*).

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