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An adult of *Folsomia candida* (Willem) (Collembola: Isotomidae). Photograph by Renate Snider.
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THE LIFE HISTORY OF *FOLSOMIA CANDIDA* (WILLEM) (COLLEMBOLA: ISOTOMIDAE) RELATIVE TO TEMPERATURE

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INTRODUCTION

The parthenogenetic mode of reproduction in Collembola, although frequently questioned in the past (Schaller, 1953; Mayer, 1957; Falkenhan, 1932), has only recently been recorded and confirmed for several species; *Onychiurus parthenogeneticus* Choudhuri (Choudhuri, 1958), *Folsomia candida* (Willem) (Goto, 1960; Marshall and Kevan, 1962; Green, 1964; Husson and Palévody, 1967), *Folsomia cavicola* Cassagnau and Delamare (Goto, 1960), *Tullbergia krausbaueri* (Börner) (Hale, 1966; Petersen, 1971), and *Isotoma notabilis* Schäffer (Petersen, 1971).

Sex-ratios in populations of the above cited species are often unknown. Existing data indicate that the composition of a population may vary with the geographical distribution of the species. Populations of *Folsomia candida* (Willem), known to be bisexual in England (Goto, 1960), have been found so far to consist entirely of females in Canada (Sharma and Kevan, 1963a) and in Michigan (Snider, 1973). Similar to *I. notabilis* and *T. krausbaueri* (Petersen, 1971), investigations throughout the year and over larger geographical areas are necessary before northern USA and Canada *F. candida* may be labeled as obligatory parthenogenetic.

Snider (1973) recorded in detail the life cycle of *F. candida* at 21°C. The present study provides information on the influence of temperature on the bionomics of the species.

MATERIALS AND METHODS

As in previous studies (Snider, 1973) plastic containers (3.5 X 2.5 cm) with clear snap-on lids, filled to a depth of 1 cm with a 1:1 plaster-charcoal substrate, were used as culture containers. Addition of distilled water ensured a constant humidity of close to 100 percent. Powdered brewer’s yeast was provided as food.

First instar juveniles were isolated and observed at 24 hour intervals throughout the duration of their life. Ecdysis, oviposition, hatching success of the eggs and mortality were recorded at each of two temperatures, 15°C and 26°C. Data previously obtained (Snider, 1973) on the bionomics of the species at 21°C were incorporated into the study for comparison.

The animals originated from the same stock cultures that had been used in previous observations. These cultures had been maintained in the laboratory continuously for eight years. Recently, additional stock cultures were started with specimens collected from loose soil near Lansing, Michigan; preliminary investigation indicated that this population consisted entirely of females. For corroboration of the data obtained on “old stock” individuals, isolated “new stock” specimens were reared at 21°C, using the methods described above. Observation of this check series was discontinued after 180 days.

LONGEVITY AND MORTALITY

Longevity of Collembola is temperature dependent and most probably species specific (Thibaud, 1970). Under laboratory conditions, which usually imply rearing at constant temperature, several species have been cultured for more than a year at temperatures between 5°C and 20°C (Milne, 1960; Strebel, 1932; Joosse and Veltkamp, 1971). In general, a rise in temperature shortens the life span of Collembola.

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1 Support was provided by the Michigan Agricultural Experiment Station, for which this is Journal Article Number 6386.
Table 1. Life span, in days, of *Folsomia candida* (Willem) at three temperatures.

<table>
<thead>
<tr>
<th></th>
<th>15°C</th>
<th>21°C</th>
<th>26°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>240.6</td>
<td>136.2</td>
<td>72.4</td>
</tr>
<tr>
<td>Range</td>
<td>19-352</td>
<td>6-198</td>
<td>35-115</td>
</tr>
</tbody>
</table>

Fig. 1. Survival of *Folsomia candida* (Willem) at three temperatures. Data for 21°C “old stock” taken from Snider (1973).

The mean life span of *F. candida* at 15°C was 240 days as compared to 136 days at 21°C (Snider, 1973). At 26°C longevity was reduced to an average of 72 days (Table 1).

Survival was drastically reduced at 26°C, with 50% of the individuals dead after 70 days. At 21°C 50% of the animals had died after 150 days, whereas at 15°C mean survival was prolonged to 258 days. Longevity and survival pattern of “old stock” and “new stock” individuals reared at 21°C showed no significant differences with mean survival in both series reaching approximately 150 days (Fig. 1).

The number of instars in a life time also was temperature dependent. At both 15° and 21°C an average of 30 instars was completed. At 26°C no female underwent more than 22 instars, with a mean of 16 instars per individual.

**INSTAR DURATION**

In *Tullbergia krausbaueri*, several species of *Onychirus*, and a number of *Hypogasturidae* instar duration tends to increase with progressing age (Hale, 1965a; Choudhuri, 1961; Thibaud, 1970). These data confirmed previous findings by MacLagan (1932) and Davis and Harris (1936) for other species. Hale (1965a) showed a relationship between instar duration and temperature. This was further exemplified by Thibaud (1970) who demonstrated that in a given species temperatures close to the upper lethal limit induce a considerable increase in instar duration.
At all experimental temperatures the first instar stadium of *F. candida* was of longer average duration than the subsequent three or four stadia. This agrees with Green's observations at 25°C (Green, 1964). Mean duration of the stadia in aging individuals was found to be almost twice as long at 15°C than at 21°C (Table 2). At 26°C the duration of the stadia was occasionally longer than at lower temperatures. Occurrence of uncommonly wide ranges (3 to 26 days for the 5th stadium, 4 to 30 days for the 11th stadium) and frequent intervals of 9 to 17 days between moults indicate that 26°C possibly approaches the upper limit of tolerance for *F. candida*.

At 21°C intervals between moults in "old stock" and "new stock" individuals were not significantly different (Table 2). A relevant cause for occasional discrepancies may be found in the relatively low number of "new stock" replicates observed.

Although the reproductive rhythm in *F. candida* is well defined (Snider, 1973) it is not reflected in the duration of the stadia. In other species, periodic deposition of eggs and spermatophores relates to marked differences in the length of the stadia; sometimes in males only (Poggendorf, 1956; Mayer, 1957; Waldorf, 1971); sometimes in both males and females (Joosse and Veltkamp, 1970; Thibaud, 1970). So far as has been observed, none of the known parthenogenetic species have alternating long and short stadia which can be related to egg production.

**EGG PRODUCTION**

Hale (1965b) gives a synopsis of fecundity estimates for a number of Collembola species. The estimated number of ovipositions usually varies between two and four, but occasionally rises to ten probable ovipositions, as in *Tullbergia krausbauri*. This species was later proven to reproduce parthenogenetically (Hale, 1966; Petersen, 1971). Sharma and Kevan (1963b), dealing with a bisexual population of *Isotoma notabilis*, recorded a maximum of four ovipositions at intervals of six days. Petersen (1971) gives no account of the number and timing of egg depositions in *I. notabilis*, though he established that the species reproduces successfully in the absence of males.

A direct relation between ecdysis and oviposition was found in *T. krausbauri* as well as in two species of *Dicyrtoma* (Hale, 1965b). In these egg laying always occurs directly after molting, often in successive instars. The same is true for *Protaphorura armatus* where older females often lay eggs while the exuvia is still attached to the dorsal end of the abdomen (unpublished data). Waldorf (1971) found that females of *Sinella curviseta* begin to oviposit eight hours after ecdysis, with a tendency toward alternating productive and non-productive instars. A similar sexual rhythm was described for both males and females of *Isotoma viridis* and *Tomocerus minor* by Joosse and Veltkamp (1970) who in turn linked spermatophore and egg production to alternate stadia of longer duration.

In *F. candida* a somewhat irregular egg laying rhythm was noted by Green (1964), with intervals of up to three instars between ovipositions. However, both in past observations (Snider, 1973) and in the present study, *F. candida* was found to oviposit with great regularity, there being alternating productive and non-productive instars at all experimental temperatures. The majority of the intervals between ovipositions encompassed two instars; variation was greatest at 26°C and least at 15°C (Table 3).

As the experiment progressed, it became clear that at 15° and 21°C eggs were laid predominantly in the 6th, 8th, 10th... instars. At 21°C 100 percent of all females followed this pattern; however, at both 15° and 21°C slight variations in the percentage of laying females were brought on by pauses in oviposition and by occasional deposition of eggs in consecutive instars, especially in older females. At 26°C only 52.6% started laying in the 6th instar and the remaining females laid their first batch of eggs in the 7th or 8th instar. This difference in the time of initiation of egg production at 26°C, coupled with greater variability of the intervals between ovipositions, altered the 6-8-10th instar rhythm predominant at lower temperatures (Table 4). Examples of egg production by single females, as given in Fig. 2, demonstrate that both the 6-8-10th instar and the 7-9-11th instar rhythm were common at 26°C.

Compared to "old stock" reared at 21°C (Snider, 1973) females kept at 15°C showed greatly increased egg production, with the increase being significant at the 1% level.
Table 2. Average duration, in days, of selected stadia of *Folsomia candida* (Willem) at three temperatures (number of replicates in parentheses). Data for 21°C "old stock" taken from Snider (1973).

<table>
<thead>
<tr>
<th>Instar</th>
<th>1</th>
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<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>34</th>
<th>38</th>
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<tbody>
<tr>
<td>15°C</td>
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<td></td>
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</tr>
<tr>
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<td>7.0</td>
<td>5.2</td>
<td>5.5</td>
<td>5.5</td>
<td>6.5</td>
<td>6.3</td>
<td>6.9</td>
<td>7.2</td>
<td>7.0</td>
<td>8.0</td>
<td>11.3</td>
<td>10.0</td>
<td>9.8</td>
<td>11.3</td>
<td>11.1</td>
<td>12.7</td>
</tr>
<tr>
<td>21°C old stock</td>
<td>4.0</td>
<td>3.7</td>
<td>4.5</td>
<td>4.2</td>
<td>4.1</td>
<td>4.7</td>
<td>4.9</td>
<td>5.6</td>
<td>5.5</td>
<td>5.5</td>
<td>5.7</td>
<td>6.7</td>
<td>7.0</td>
<td>7.0</td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td>21°C new stock</td>
<td>4.8</td>
<td>3.7</td>
<td>4.8</td>
<td>5.4</td>
<td>5.7</td>
<td>5.4</td>
<td>5.6</td>
<td>5.9</td>
<td>6.6</td>
<td>6.5</td>
<td>6.3</td>
<td>7.0</td>
<td></td>
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</tr>
<tr>
<td>26°C</td>
<td>5.4</td>
<td>3.2</td>
<td>4.0</td>
<td>5.3</td>
<td>4.4</td>
<td>4.6</td>
<td>4.8</td>
<td>5.2</td>
<td>4.9</td>
<td>6.4</td>
<td>6.4</td>
<td>5.3</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

The data for 21°C "old stock" are taken from Snider (1973).
Fig. 2. Egg production by nine single females of Folsomia candida (Willem) at 26°C.
Table 3. Intervals, in instars, between ovipositions of *Folsomia candida* (Willem) at three temperatures.

<table>
<thead>
<tr>
<th>Intervals in instars</th>
<th>Percent of all observed intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15°C</td>
</tr>
<tr>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>2</td>
<td>97.3</td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>4</td>
<td>1.6</td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Percentage of egg laying females of *Folsomia candida* (Willem) in instars 6 through 18.

<table>
<thead>
<tr>
<th>Instar</th>
<th>Productive females, in % of all females alive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15°C</td>
</tr>
<tr>
<td>6</td>
<td>86.6</td>
</tr>
<tr>
<td>7</td>
<td>10.0</td>
</tr>
<tr>
<td>8</td>
<td>90.0</td>
</tr>
<tr>
<td>9</td>
<td>10.0</td>
</tr>
<tr>
<td>10</td>
<td>90.0</td>
</tr>
<tr>
<td>11</td>
<td>10.0</td>
</tr>
<tr>
<td>12</td>
<td>90.0</td>
</tr>
<tr>
<td>13</td>
<td>10.3</td>
</tr>
<tr>
<td>14</td>
<td>82.7</td>
</tr>
<tr>
<td>15</td>
<td>6.8</td>
</tr>
<tr>
<td>16</td>
<td>89.6</td>
</tr>
<tr>
<td>17</td>
<td>3.7</td>
</tr>
<tr>
<td>18</td>
<td>96.3</td>
</tr>
</tbody>
</table>

Females at 15°C commonly laid from 160 to over 200 eggs during one oviposition, while the highest number of eggs recorded at 21°C was 157. No more than 44 eggs were laid in any given instar at 26°C and none of the females produced more than 209 eggs in a life time (Table 5). The mean number of ovipositions per female was 13 at both 15° and 21°C and only five at 26°C.

Table 5. Average and maximum egg production per female of *Folsomia candida* (Willem) in a life time. Data for 21°C taken from Snider (1973).

<table>
<thead>
<tr>
<th></th>
<th>15°C</th>
<th>21°C</th>
<th>26°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean total/ fem./ life</td>
<td>1344</td>
<td>1011</td>
<td>130</td>
</tr>
<tr>
<td>Max. eggs by one female</td>
<td>2355</td>
<td>1654</td>
<td>209</td>
</tr>
</tbody>
</table>
Animals of "new stock" origin reared at 21°C showed an egg laying pattern as well as a fecundity rate similar to "old stock" individuals. Discrepancies in the timing of fecundity peaks are thought to be due to the great difference in the number of replicates observed (Fig. 3).

In order to include all eggs laid per female, the data on egg production per instar were summarized in groups of two instars (Fig. 4). Females reared at 15°C were clearly the most productive. A temperature of 26°C drastically reduced the number of eggs laid; the relatively low number of ovipositions was due to increased mortality, since all females laid eggs until a short time prior to death. In *Isotoma notabilis* the process is somewhat reversed; at temperatures lower than the recorded optimum (17°C) the number of laying periods is reduced, although the animals apparently live long past the attainment of maturity (Sharma and Kevan, 1963b).

At 15°C a mean of 27.5 (24-43) days elapsed from the day of hatching to the first oviposition, as compared to 17.7 (16-25) days at 21°C. At 26°C longer instar durations slightly delayed the onset of egg production. A mean of 20.6 days of development with a range of 15-42 days was needed until the first oviposition.

**EGG VIABILITY**

The presence of non-viable eggs in a batch of otherwise viable eggs has been recorded in the past (Waldorf, 1971; Marshall and Kevan, 1962) and may be a common occurrence in Collembola. At the first oviposition of *Isotoma notabilis*, Sharma and Kevan (1963b) noted small eggs which failed to develop and related the phenomenon to possible...
FOLSOMIA CANDIDA (WILLEM) egg production

Fig. 4. Average egg production per female of Folsomia candida (Willem) at three temperatures.

Immaturity of the females. In F. candida a somewhat similar observation was made (Snider, 1973). Moreover, a pattern in egg viability throughout the life of the females was established: hatching success increases concurrently with the increase in egg production and decreases with progressing age and decreasing fecundity.

Data obtained previously (Snider, 1973) on viability of eggs at 21°C are not included in the presentation of results. "Old stock" individuals at 15°C and 26°C and "new stock" at 21°C, all of which were reared concurrently, allowed a more valid comparison of data in view of the time when observations were made. Imperceptible changes in the technique of handling and counting eggs may have contributed to discrepancies between present and past data.

The first batch of eggs showed a relatively low viability at all temperatures. Generally, 15°C proved to favor egg viability more than either of the higher temperatures. At 26°C viability rose to 87.7% in the 10th instar, then declined rapidly and somewhat irregularly. At any time from the second to the 10th oviposition, females at 15°C laid highly viable eggs (96 to 98%) and at 21°C viability reached a level of about 95%. Decrease in viability with age was found to be gradual, with a low of 90% in the 18th oviposition at 15°C (Table 6).

SUMMARY

Parthenogenetic females of Folsomia candida (Willem) were reared in isolation at 15°C and 26°C and observed throughout their life time. Results were compared to previously obtained data on the bionomics of the species at 21°C (Snider, 1973).

1. Duration of the stadia in older females was about twice as long at 15°C as it was at 21°C. A 26°C temperature slightly lengthened instar duration, indicating that 26°C may approach the species specific upper temperature limits. At all temperatures intervals between mouls lengthened with progressing age.

2. A temperature of 26°C shortened the life span to a mean of 72 days as compared to 136 days at 21°C. At 15°C average longevity was extended to 240 days. Mortality reached 100 percent after 115 days at 26°C, 198 days at 21°C and 352 days at 15°C.

3. Egg production was highest at 15°C. The maximum number of eggs laid in a life time was 209 eggs at 26°C, 1654 eggs at 21°C and 2355 eggs at 15°C. Productive and
Table 6. Viability, in percent, of eggs of *Folsomia candida* (Willem) at three temperatures.

<table>
<thead>
<tr>
<th>Ovipos.</th>
<th>Instar</th>
<th>old stock 15°C</th>
<th>new stock 21°C</th>
<th>old stock 26°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>86.6</td>
<td>74.7</td>
<td>73.5</td>
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<tr>
<td>2</td>
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<td>18</td>
<td>40</td>
<td>90.1</td>
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</table>

non-productive instars alternated in a distinct rhythm, although irregularities were common at 26°C. At both 15° and 21°C temperatures, a mean of 13 ovipositions was recorded per female, whereas at 26°C the number of layings averaged five.

4. Egg viability was highest at 15°C. In general, hatching success was low at the first oviposition; it increased with increasing fecundity and decreased with progressing age.

5. Females of "new stock", collected in the field prior to the investigation and reared at 21°C, showed mortality and fecundity patterns similar to those of "old stock" females originating from cultures maintained continuously in the laboratory for the past eight years.

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The authors wish to thank Dr. Ralph Pax for his assistance in the evaluation of the data, and Dr. Richard J. Snider for his valuable criticism throughout the duration of the study, which was carried out under the Department of Entomology Soil Biology Project at Michigan State University.

LITERATURE CITED


Subterranean termites have been present in Michigan for a long time. They were reported as being destructive to buildings in 1920 (Anonymous, 1961), and apparently damage done at that time was increasing over what had occurred earlier. Notwithstanding this long time presence of termites in the state a majority of the population still looks upon the termite as a strange insect most likely to be encountered in the South. All too many home owners and building proprietors as well as others are unacquainted with presence of termites in their areas. At the same time monetary loss due to termite attack is considerable. As an example, control costs and losses to structures in Tennessee due to termites in 1971 were reported (Anonymous, 1972) as over $8 million. Expenditures are less than this in Michigan but still substantial. Because of these facts it was felt that a wide cross-section of the public would benefit from knowledge of locations in Michigan where termites are present and most likely to cause damage. Unfortunately the general public is not aware that there are effective control methods to prevent damage where termites are a hazard.

*Reticulitermes flavipes* (Kollar) is the most commonly encountered termite in Michigan. Other species found in the State are *Reticulitermes arenincola* Goellner and *R. tibialis* Banks. *Areninocola* is reported from the very southwest corner of the State and *R. tibialis* is known from scattered localities.

**SPREAD OF TERMITES**

One of the first questions asked by the public in regard to termite activity is, "How did they get here?" I doubt that anyone can say for sure just where or when they entered Michigan. They may have been in the Lake States area since prehistoric times. The likelihood is that they moved northward from the South. Even now there is evidence that termites are moving farther north, or at least damage is appearing in colder locations. The records, in this respect, for Michigan are skimpy but we can look at other areas in the United States and Canada and apply the observations here.

Subterranean termites have been found (Anonymous, 1968) in Roundup, Ryegate, Billings, Livingston and Ekalaka, Montana. All of these places are farther north than Alpena. Going even farther north, observers (Anonymous, 1961) have found an office building in Superior, Wisconsin, infested and in North Dakota (Anonymous, 1963) termites have been found in east central McKenzie County which is at a latitude of about 48° north. This is farther north than any point in Michigan other than Isle Royale. Figure 1 shows the approximate locations of these infestations. Thus, geographical location is not a safeguard in this state; at least its northerly location is not.

How did these insects get into places like Superior, Wisconsin, and Toronto and Kincardine, Ontario, when they are not known for a hundred miles around? In these cases it is likely that they were brought into these cities on wood or soil. In Toronto the first indication of termite activity was along the waterfront (Urquhart, 1953) while in Kincardine termites were first found in some debris along the railroad-harbor terminal.

What happens after termites become established at a new location? The infestation in Toronto spread rapidly. In less than 25 years termites were found several miles from the original infestation and in most sections of the city and several suburbs. On the other hand the spread of termites in Sheboygan, Wisconsin has been much slower. Fully satisfactory explanations for this difference are lacking.

They can then extend their range by mating flights when winds might carry them as much as a mile from their original habitation. A third way is through tunnels in the soil.

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Maps of infested areas of the two Ontario cities indicate that both of these pathways are involved. No detailed studies of this kind have been made in Michigan but it is a safe bet that related patterns would be found.

**Sources of Information**

The State of Michigan is in a fringe area as far as termite distribution is concerned. States to the south would have termites in all counties but here termites in many counties are still rare or nonexistent at present, much to the relief of homeowners. On the other hand they increase in numbers toward neighboring states to the south. These intermediate areas are of most interest because it is here where builders and homeowners have to decide whether they want to spend money for termite protection or not. In heavily infested areas the question is already answered for them.

There are several approaches to locating termite activity. Bait stakes can be buried in soil throughout the area for examination in six months to a year. This scheme was followed in southern Ontario (Kirby, 1965) some years ago when 1200 stakes were set in soil from Toronto to Hamilton and then over to Sarnia. Only stakes in Toronto became infested. This approach is somewhat costly, time consuming, and samples only a very small portion of large areas. In addition plain wood stakes seem to be unattacked by small colonies in the vicinity. Bait stakes with attractant are best for use in a city or small area to pinpoint trouble spots as was done in Kincardine (Gray, 1969). This procedure should prove to be a useful tool in Michigan if used in a similar way but was not adopted for this statewide survey.

Pest control operators were deemed to be the best source of information because they encounter termites in their day to day activities. They were suggested by entomologists, real estate boards and governmental housing agencies. Accordingly, termite control companies were the chief source of information on which this study was based.
In consultation with the National Pest Control Association a questionnaire was composed that was sent to all members in Michigan, northern Indiana and northern Ohio. A 51% response was obtained. Personal interviews were also held with most of the larger firms in the termite business in Michigan. County extension directors, building officials, and district foresters in Michigan were sent other questionnaires.

Response of building officials was also quite gratifying as far as percentage of returns was concerned; 108 of 219 or 49% replied. However, a considerable proportion disqualified themselves because they did not perform inspections of older houses. Estimates of percentage of termite infested buildings by building officials did not always agree with those of the TCO (Termite Control Operators). The general pattern of termite distribution as reported by them, however, confirmed TCO's observations in many counties.

The mailing to TCO's asked how many termite jobs per year for the past five years were carried out. County Extension Directors were asked how many inquiries on termites they had received in the last five years. Obviously these are not the same, but inquiries are an indication, in large part, of termite activity in a county. Information from the two sources agreed quite well.

COUNTY TERMITE ACTIVITY

Table 1 lists counties in Michigan from which subterranean termite activity has been reported and includes an estimate of percentage of infested buildings. Those counties which were reported to have had a few cases of termite attack or observation in the last five years are so designated. If there is a blank in the "activity" column there was no attack reported. These would be border counties next to termite-free counties.

A few explanations are in order for some counties. Genesee reported virtually no termite activity by TCO's but a building official in a township bordering on Flint noted that a number of substandard dwellings with very low foundations built in 1935 or thereabouts had been infested with termites. Grand Traverse was cited as having had one case of termite infestation in a lumber company storage warehouse that was heated. This infestation was eliminated and there has apparently been no reinfestation. Gratiot County was not mentioned by any TCO contacted or the county extension director as having termites but St. Louis, Michigan, was listed by a building official as having some infested houses.

Ingham County lies between Eaton and Livingston both of which have termites; however, it is reported to have but few instances of termite infestation of buildings. Over the years a few control jobs have been done in Lansing and East Lansing. The district forester reported termite presence in a woods near Stockbridge. A large swarm from an extensive infestation was reported on March 22, 1971, in Lansing (Anonymous, 1971) so the threat is there.

It is generally agreed among TCO's that thumb counties, Huron, Tuscola, Sanilac, Lapeer, and Saint Clair have very little termite activity. Macomb is also surprising because it borders on Lake Saint Clair, has a milder climate, is next to counties that do have infestation, but still is reported to have very few termites.

Counties omitted from Table 1 were not designated by any of the groups queried as having termite activity. These were all of the Upper Peninsula and those in the northeastern part of the Lower Peninsula as well as Clinton, Shiawassee, Saginaw and Bay. Figure 2 is a map of Michigan with counties shaded to show estimated percent of buildings infested in the county. Figure 3 illustrates termite distribution-intensity information by use of lines of equal intensity in an attempt to show graduations better. Neither of these maps can be precise but they do give a balanced estimate. Someone in Kent or Kalamazoo County, for example, should be wary of termite attack, and be informed if he is building or buying houses or other buildings containing wood, wallboard, hardboard, particle board and the like. No doubt there will be those who object to estimates allotted to a county compared to their own experience. I acknowledge that these are estimates based on observations of many people, and there may be some not contacted who have more precise information. It would also be interesting,

COUNTY TERMITE ACTIVITY
Table 1. Termite activity in Michigan by county. Counties not listed have no termites.

<table>
<thead>
<tr>
<th>County</th>
<th>Activity Reported By</th>
<th>TCO Estimated % Infested Buildings</th>
<th>CED Inquiries Per 10,000 Population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TCO CED or BO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allegan</td>
<td>x</td>
<td>15</td>
<td>Many</td>
</tr>
<tr>
<td>Barry</td>
<td>x</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>Benzie</td>
<td>@</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>Berrien</td>
<td>x</td>
<td>&gt;20</td>
<td>3</td>
</tr>
<tr>
<td>Branch</td>
<td>x</td>
<td>7</td>
<td>28</td>
</tr>
<tr>
<td>Calhoun</td>
<td>x</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Cass</td>
<td>x</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Eaton</td>
<td>x</td>
<td>3</td>
<td>.6</td>
</tr>
<tr>
<td>Genesee</td>
<td>@</td>
<td>&lt;1</td>
<td>1</td>
</tr>
<tr>
<td>Grand Traverse</td>
<td>@</td>
<td>0</td>
<td>.3</td>
</tr>
<tr>
<td>Gratiot</td>
<td>@</td>
<td>0</td>
<td></td>
</tr>
<tr>
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<td>x</td>
<td>4</td>
<td>21</td>
</tr>
<tr>
<td>Ingham</td>
<td>@</td>
<td>&lt;1</td>
<td>0</td>
</tr>
<tr>
<td>Ionia</td>
<td>x</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Jackson</td>
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<td>3</td>
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<tr>
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</tr>
<tr>
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<td>25</td>
</tr>
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<td>48</td>
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<tr>
<td>Lapeer</td>
<td>@</td>
<td>&lt;1</td>
<td>.4</td>
</tr>
<tr>
<td>Lenawee</td>
<td>x</td>
<td>2</td>
<td>.5</td>
</tr>
<tr>
<td>Livingston</td>
<td>x</td>
<td>2</td>
<td>22</td>
</tr>
<tr>
<td>Macomb</td>
<td>x</td>
<td>&lt;1</td>
<td></td>
</tr>
<tr>
<td>Manistee</td>
<td>x</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Mason</td>
<td>x</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Mecosta</td>
<td>@</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>Monroe</td>
<td>x</td>
<td>3</td>
<td>21</td>
</tr>
<tr>
<td>Montcalm</td>
<td>x</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Muskegon</td>
<td>x</td>
<td>14</td>
<td>32</td>
</tr>
<tr>
<td>Newaygo</td>
<td>x</td>
<td>7</td>
<td>36</td>
</tr>
<tr>
<td>Oakland</td>
<td>x</td>
<td>&lt;1</td>
<td></td>
</tr>
<tr>
<td>Oceana</td>
<td>x</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Ottawa</td>
<td>x</td>
<td>15</td>
<td>63</td>
</tr>
<tr>
<td>St. Joseph</td>
<td>x</td>
<td>10</td>
<td>22</td>
</tr>
<tr>
<td>Tuscola</td>
<td>@</td>
<td></td>
<td>0.4</td>
</tr>
<tr>
<td>Van Buren</td>
<td>x</td>
<td>&gt;20</td>
<td>27</td>
</tr>
<tr>
<td>Washtenaw</td>
<td>x</td>
<td>2</td>
<td>.1</td>
</tr>
<tr>
<td>Wayne</td>
<td>x</td>
<td>1</td>
<td>.9</td>
</tr>
<tr>
<td>Wexford</td>
<td>x</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

BO = Building Official
TCO = Termite Control Operator
CED = County Extension Director
x = Positive
@ = Rare or Minimal
- = Not reported
useful and informative to study certain areas, counties, parts of counties or cities with bait stakes to pinpoint termite presence and rate of spread.

One reason data shown may not agree with an observer's information is that termite infestation can vary greatly within a county or city. Values shown are averages. There may be some streets or blocks where infestation is almost 100% while in other parts of town there are no known termite infestations. This was closely studied at Kincardine (Gray, 1969). While no such intensive study has been made in Michigan, some observations illustrate a related situation. For example, in Oakland County termites are
active near Walled Lake, Duck Lake, Ann Lake, Union Lake, White Lake, and in the southern part of the county along 8 Mile Road. Some of these places are shown on the map, Figure 4.

In Wayne County probably less than one percent of the buildings are infested on the far east side; however, infestation is increasing in the western part in Taylor, Wayne, Westland and Redford, but is still under 5% in these sections. Figure 5 designates some
Fig. 4. Lakes in Oakland and adjacent counties which have heavy termite infestations nearby.

locations of termite infestation in the Detroit area. No doubt there are other areas of infestation and a prediction is made that these infestations will increase until they touch and become one large region.

Observations in and around Grand Rapids indicate that heaviest infestations are to the southeast and would include Cascade and Kentwood. Next is the southwest quadrant with Wyoming, Grandville and Jenison all being fairly heavily infested. Then come northeast and northwest. Figure 6 shows these divisions of termite incidence.

In counties where termite infestation is more general such as Kalamazoo, Van Buren, Cass, etc. damage can be found in nearly every town and in rural situations as well. Figure 7 shows the area around Kalamazoo with many towns underlined. All thus marked were locations where one TCO had several buildings under contract for treatment. If contracts of other TCO's for the same area were known, it is likely that every town on this map would be underlined.

**INFLUENCES ON TERMITE DISTRIBUTION AND ACTIVITY**

The more important environmental influences on subterranean termite distribution are mentioned here.

Moisture is certainly important. These insects need an ample supply for their metabolic and structural and destructive activities. They obtain water they need from the soil although there are instances where colonies were established on barges or vessels with no soil present. Moisture enters soil from precipitation, surface runoff and subsoil drainage. Influence of moisture is seen especially in areas of sparser termite infestation such as in Livingston or Oakland Counties where active locations are near lakes. Another is in the city of Otsego where 70% of the buildings are reported to be infested. This high incidence is attributed in part to a high water table and heavy rainfall.
Fig. 5. Location of known termite infestations in the Detroit Metropolitan area.
Fig. 6. Severity of termite infestations in the Grand Rapids area. 1 = highest, 4 = lowest.

Fig. 7. Towns in Kalamazoo area in which one TCO has contracts for termite control in buildings (underlined).
Soil type is important. According to Kofoid (1934) *Reticulitermes* prefer sandy soil over clay soil by a wide margin. Mechanical structure and water holding capacity are also of interest. Apparently even less water is needed in sandy soil for ready excavation by *R. hesperus* than in sandy loam. This preference of some termites for sandy soils can be seen in Michigan. Most counties with the greatest frequency of termite infestation are those with some of this type of soil including Oceana, Newaygo, Muskegon, Kent, Ottawa, Allegan, Van Buren, Berrien, and Cass. Soils of Barry, Kalamazoo, Calhoun, and St. Joseph are largely sandy loams but still apparently sandy enough to encourage considerable termite activity. Figure 8 is a map of Michigan with areas in the southern and
western regions marked to show sandy and sandy loam soils. This map is based on soil associations in the bulletin by Whiteside et al. (1968).

Latitude is sometimes cited as a limiting influence on termites. This is closely linked with temperature. Low temperature is limiting, but subterranean termites can survive in an intolerably cold climate if they are warmed by artificial heat of a building escaping to the surrounding soil. Esenther (1961) found that termites could survive subfreezing temperatures in the 20-25°F range during observations in Janesville and Sheboygan, Wisconsin. There were no buildings within a quarter mile of these observed insects. As was cited earlier, subterranean termites have been found in Montana and North Dakota which have a colder soil temperature than Michigan. Thus, latitude is probably less important than resulting temperature from escaped heat into soil. It is also an indication that outdoor temperature is not a safe limiting condition in Michigan for termite attack in heated buildings.

Food is a prime requirement and not very limiting to termite distribution because cellulose is so widespread that there is hardly a place where it is not found in some form. Life is made easier for termites by inadvertent and careless acts of man. There is no point in dwelling on such careless acts as burying wood debris around new houses and other buildings. It is well known that this leads to termite infestation and most cities and communities have codes outlawing the practice, but how stringently is the code enforced? As subdivisions continue to be built in old orchards without enough attention paid to destruction of stumps and old branches termite infestation will be encouraged. In Michigan another source of wood is leftover from lumbering days of the '90's. The high incidence of termite infestation in the Muskegon area is attributed in large measure to huge amounts of old white pine sawdust that was used for fill. Cadillac is another city that owes infestation, in part, to the plentiful supply of sawdust and wood residue left after lumbering days.

Besides moisture, soil, temperature, and food sources there are other factors that determine termite distribution. Only one of these, the presence of natural or man-made barriers, is discussed here. The water barrier of the Great Lakes and connecting rivers has probably limited access of termites to southern Ontario. That is to say without the presence of all this water termites would be more widespread in this part of Canada. At Kincardine a river and a state highway were barriers which kept termites from spreading to other parts of town. This can be seen from Figure 9 taken from the late Mr. Gray's fine article. Likewise termite spread to the upper peninsula may eventually be contingent on their ability to get across the Straits of Mackinac, although they would not be so barred on the west side of Lake Michigan.

NATURE AND EXTENT OF DAMAGE AND INFESTATION

The Federal Housing Administration has taken steps to control termite infestations by requiring inspection of structures before they can be sold. These inspections are made by TCO's and they are also made for real estate boards where a property is sold under non-FHA supervision. Counties in which FHA requires such certification are: Lenawee, Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw, and Wayne, in the southeastern part of the state and Allegan, Barry, Berrien, Branch, Calhoun, Cass, Hillsdale, Ionia, Jackson, Kalamazoo, Kent, Muskegon, Ottawa, St. Joseph, and Van Buren in the southwestern part. These counties are shown on Figure 10. This figure should be compared to Figures 2 and 3.

In more heavily infested counties of Michigan pre-treatment of structures with insecticides is practiced, see Figures 2 and 3. Like any other preventive treatment it must be carried out thoroughly to be effective. Unreasonably low bids for such work are cause for suspicion. Inspection after application is diminished in value because there are no simple field methods of quantitative estimation of the chemicals used.

An estimate based on TCO response taking into consideration percentage and size of the firms would indicate somewhere between 7,000 and 8,000 structures are treated per year in Michigan at an average cost of $225. This does not include pre-treatment work. Thus, about $1,600,000 is spent per year for remedial termite protection at present and very likely will increase.
Fig. 9. Distribution of subterranean termites in Kincardine, Ontario, Canada in 1968-1969. From Gray's 1969 paper.
A listing of structures or objects reported as being infested with termites follows: houses, office buildings, stores, motels, industrial buildings, park shelters and pavilions, churches, schools, summer cottages, farm buildings, fences, hardwood sawdust piles, stored lumber and timbers, fallen trees and logs, stored firewood, and tree stumps.

One of the questions asked was whether incidence of termite infestation was increasing, decreasing or remaining steady. More than 70% of the TCO's believe it is
increasing. Some of this may be more awareness of the problem on the part of the public, but more treatments in counties where a few years ago there were few or none is a sign of increase.

To sum up, termites are here to stay in Michigan. They are confined to the lower peninsula and reach their greatest activity in the southwestern counties. They may be concentrated in a few places in some counties while present in nearly every town and wooded area in others. Sandy soils and shore areas are especially to their liking. Heated buildings and basements make termite establishment possible almost any place in Michigan. Termite infestation appears to be increasing in the state. It behooves homeowners, builders, government officials, real estate people and, of course, termite control operators to be familiar with the problem and its control.

LITERATURE CITED


A recent study of dragonfly names (Montgomery, 1973) has led to a consideration of insect names, especially ancient and early English names. This interest was aroused, chiefly by the statement in Sarot's study of the folklore of the dragonfly from "A Linguistic Approach" that no recognizable name for dragonflies has been found in Anglo-Saxon, classical Latin or ancient Greek. Any language is capable of supplying names for all objects, including insects, which are recognized by its community of speakers. As so many names for dragonflies have been found in modern languages, (95 in English, over 60 in German, about 40 in French and almost 200 in Italian) and names for other insects are fairly numerous in these languages (for example: at least 13 for grasshopper or locust, eight for beetles, and six each for moth, fly and cicada in ancient Greek) this is surprising if not incredible. However, in several years of search I must say that I have been as unsuccessful as Sarot. The search is made rather difficult because all of the comprehensive dictionaries and glossaries of these languages which I have found are one-way, that is from the other language into English. Search for an English word in them is comparable in difficulty to getting where you wish to go by traveling the wrong way on a lane of a super-highway! A great amount of data on insect names in general has been acquired.

Names of insects are usually considered to be of two kinds—common and scientific or technical. Common names are those of the vernacular, or of ordinary language, plain English. Scientific names are Latin, at least, in form, and comprise a system of nomenclature, governed by an elaborate set of rules—The International Code of Zoological Nomenclature.

Common names are generally thought to be folk names developed by the usage of common people. Therefore, they are simple, familiar and generally understood by everyone. Perhaps, even the specialist should use them to maintain rapport with his audience, whoever that may be! Technical names are thought to be "manufactured" by taxonomists through the process of assembling bits and pieces of language (technically roots and affixes) into meaningful, but strange, exotic and incomprehensible terms. Thus, technical insect names are regarded by the non-taxonomist with the usual suspicion given to the jargon of the professional—the physician, the lawyer, the professor, etc. Even the economic entomologists have their own set of "approved" common names which are required in papers published in the professional journals. Can you imagine the haematologist or the dermatologist using common names for diseases of the blood or the skin in articles in a technical medical journal?

The presumed distinctions and differences between common and technical names are to a considerable degree spurious. Latin and Greek language elements are difficult only because of the unfamiliarity of the public at large, even the so-called intellectual community, with scientific nomenclature and terminology.

This unfamiliarity is probably due more to the specialization and exactness of scientific concepts than to the language. The student of the arts, or the humanities, is generally unalterably, seemingly almost congenitally, opposed to the type of detail and preciseness which constitute the everyday practices of the scientist. Furthermore, the English language is about three-fifths Latin, and the language, at least the writings, of any professional Biologist is probably more nearly four-fifths Latin and Greek derived. All of us have had our course in classical derivatives,—or wish we had, as we thumb through the glossaries of Brown (1956), Borror (1960), Jaegar (1944), Nybakken (1959), or Stearn (1966).

Insect names may be classified as to origin into some six groups, which are not at all mutually exclusive—primitive, borrowed, extended, associative, descriptive and synthetic. These groups are my own classification and may not correspond to the linguistic classifications of the origins of the words of a language.
Primitive names are those so old in the development of a language that no information about their origin, except from primitive roots as determined from comparative etymology, is available. In English such names can be traced back through Anglo-Saxon to proto-Germanic, and frequently to basic Indo-European. In most cases there are cognate names in related languages. They include such insect names as ant, bee, beetle, fly and wasp. The word bee may be traced back through some changes in spelling (bee-bey-be) to the Anglo-Saxon Beō, and old Teutonic bion from the root bi-, likely from the Indo-European root bhi-, to fear, in the sense of quivering, on the basis of buzzing or humming. There are cognate forms in German (Biene) and Dutch (bij). The development of a primitive name may be well illustrated by a study of adder, which is an element of many associative names for dragonfly in English (23) and Celtic (11). This word may be followed backward in a variety of spellings through Middle and Old English: adder-addre-addir-ather-eddyre-naedre which was close if not identical with the Anglo-Saxon. The original meaning was merely snake and the specialization to apply to a particular kind of snake developed relatively late. The initial n- was lost in Middle English (about 1300-1500) to the article, a nadder, becoming an adder. (For the opposite development note newt—an aut becoming a newt.) It is interesting that a variety of spellings of adder, going back to the 10th century, have survived in dialect form and appear in the local names for dragonfly in British provincial areas (English Dialect Dictionary, Wright, 1962). Cognate forms in Irish, Scottish, Welsh and Breton dialects are shown in the list of Celtic names for dragonfly (Montgomery, 1973). Other cognate forms are found in Dutch (adder), German (Natter), Latin (natrix) and Sanscrit (naga). All appear to be derived from the Indo-European root, (s)ne-, to wind, or to twist.

Borrowed names are words from other languages. They are adopted when the community of speakers of a language are in contact with another language which has an appropriate name for an insect, particularly if the insect is “new” to the experience of the borrowing language community. Borrowed names are frequently modified, sometimes considerably, into the pattern of the new language by folk etymology. The name cockroach is an excellent example of such a borrowed name. It came into English about 1600 through the writings of Capt. John Smith who interpreted the Spanish cucaracha as cacarootch. “A certaine India Bug, called by the Spanish a Cacarootch, the which creeping into Chests they eat and defile with their ill-scented dung.” (Oxford Dictionary, Murray et al., 1933). Smith's rendition of the Spanish name was near a combination of two English words—cock, a male of the domestic fowl and roach, a carp-like fish (Leuciscus rutilus) although each word has several other meanings. Thus, the name for the insect, which probably soon became very familiar to the English speaking colonists in the New World, was quickly anglicized into what appears to be a word synthesized from two familiar zoological names.

Extended names are derived by the extension of the original meaning of a word to apply to an insect which may have some direct or vague connection with this original meaning. The original meaning may in time be lost, or may continue in use in the language along side of the new meaning. A good example of a name derived by extension is bug. In spite of its simple appearance bug is not a primitive insect name, but the word seems to have been borrowed from the Welsh, bwg, with the meaning of specter, or object of terror. As the first application to an insect referred specifically to the bedbug (Cimex lectularius) the logic of the name derived by extension can be readily understood. The original meaning of the borrowed word continues to exist in the language. It might be noted in passing that bugger, a technical term in criminal law referring to pederasty, has an entirely different origin. It is derived from Old French bougre, from late Latin Bulgarus, a heretic, and originally applied to Bulgarian from a group or sect of 11th century heretics in Bulgaria, to whom the abominable practices were imputed.

Most of the 95 dragonfly names listed (Montgomery, 1973) are associative although some of the associations are fanciful as are all of those named for snakes (snakefeeder, flying adder, and even dragonfly) and some are quite imaginary, even based on false assumptions, as horse stinger, eye stinger, etc. Some are descriptive, at least in part. Such names as mosquito hawk, water dipper and balance fly are descriptive of habits of dragonflies.
There is no real distinction between common and technical names in respect to formation by synthesis. Most insect common names are dual or multiple worded, and are compounded by combining words just as technical names are composed by combining roots and affixes.

There seems to be some objection to common names selected by Professors of Entomology, textbook authors and entomological writers as not being folk names as if there is something sacred about a folk name. However, with the increasing sophistication of the general public in entomology and their increasing knowledge of different insects, additional names are necessary. Professional entomologists should be the ones to create such names. Of course, we sometimes find an author who becomes “name-happy” and creates long series of names for which there is no actual need. Such names fail to achieve acceptance and die aborning. It is likely that names have always been created by individuals. Such primitive names as the original forms of bee and adder were probably formed by some observant individual and passed on to the language community. Some ancient Aryan in the eastern Baltic area heard the buzzing of a bee or saw a snake winding through the grass. He merely shouted the substantive form of the verb roots bhi- \( \text{to quiver} \) and sne \( \text{to twist} \), and created the names for bee and snake!

One set of very interesting insect names are the Linnean generic names. Linnaeus used 89 names for genera in his class Insecta (synonymous with Arthropoda). They appeared in the first (1735), tenth (1758), and the twelfth (1766) editions of the Systema Naturae. (I have not examined the other editions but all of the Linnean names listed by Fabricius (1778) are included.) Five names listed in the first edition were omitted in the tenth—Baceros, Gyrinus, Lampyris, Lucanus and Notopeda. Gyrinus and Lampyris were used by Geoffroy in 1762, Lucanus by Scopoli in 1763 and Notopeda by Fee in 1830 (in a rewritten edition of the Systema Naturae). Baceros appears to remain without valid nomenclatural use.

An examination of these names would seem to indicate that Linnaeus did an excellent job of synthesizing names at the beginning of binomial nomenclature. Dermeles is derived from δερμα, skin, and εορν, to consume, as the name of a skin-eating beetle. Myrmeleon comes from μυρμηξ, ant, and λεων, lion, for that insect. They are, indeed, appropriate names but they were not coined by Nils Ingemarsson's son. Dermeles was used by Sophocles in the 5th century B.C., and Myrmeleon appeared in the Septuagint, the Greek version of the Old Testament made in Alexandria in the 3rd and 2nd centuries B.C. Of the 89 names (see List of Names) 82, or 91% have been identified in the glossaries of ancient Latin and/or Greek in almost the same form as used by Linnaeus, at least 56, or about 63%, were used as the names of insects in antiquity. Whether they were applied by the ancient writers to the same insects for which they are now used is not possible to determine in all cases. I presume that Linnaeus knew very little about the ancient names of insects. In fact, his student, Fabricius, implied that he knew very little about insects! Nevertheless, the glossaries cite Linnaeus frequently as authority for the insect to which an ancient Latin word referred. Twenty-four of the names were used (on one page) by Aldrovandus in 1602.

Linnaeus did not create, and at least when he first formulated his scheme of classification and first selected the names for genera, he had no intention of creating a special set of “technical names” for animals. He was a Botanist, but when he had worked out a system of classification of plants, he applied the same plan to animals and minerals. When the short manuscript (13 pages), containing the charts of classification, and very little else, was completed he went to Holland with the financial support of his future father-in-law. You may remember that there was some complaint about his spending more time dallying with the daughter of the wealthy town physician of Falun than in botanizing when he had gone to Dalecarlia on a grant of public funds to study plants. Apparently his time was well spent! Once in Holland he obtained his doctor's degree at the University of Harderwijk in a couple of weeks, and soon obtained the friendship of some of the leading scientists of the country and the support of two patrons who assisted him in publishing his Systema Naturae. From the publication of this paper in 1743 he was regarded as the outstanding authority on systematic Biology for considerably over a century—until Darwin's theory of evolution became the focal point of biological thought and classification ceased to be the main center of interest.
In the 1735 edition only genera were designated by single names, each species was designated by a diagnosis of a few words as had been the practice since Aristotle. The binary system (binomials), giving single names to species as well as to genera was not applied in detail to plants until 1735 (8th edition) and not to animals until 1758 (10th edition).

Linnaeus wrote in Latin as the common language of the educated world of his day and used the “common” Latin names for the different insects. He noted that he selected those names from other authors which belonged, or were appropriate, for genera and species(!): “Nomen Selectectum, genericum & specificum Authoris cujusdem, si quod tale, vel proprium.” I believe that most, if not all, of these names had been in wide use by writers of the 16th and 17th centuries.

In the table of names, I have indicated those which appear to be identical with ancient Latin words, whether names of “insects” or not, and the Greek word from which each was derived, if any. I have also cited a few writers, usually only those showing the earliest use of the word which I have found, and a few of the better-known authors from whom Linnaeus, or more likely, his predecessors of the 16th and 17th centuries, obtained the word. The number of these names which were used by Pliny and/or Aristotle is quite surprising, as is the great preponderance of those which are really Greek words, merely latinized. However, it must be remembered that Aristotle was the Father of Zoology and that Pliny’s Natural History was the principal zoological reference for fifteen centuries. Aslo, it must be remembered that Rome, particularly the intelligentsia, was bi-lingual throughout the classical period of Latin (from about the 2nd century B.C. to the 4th century A.D.). What was it Caesar said when he recognized Brutus among his assassins? “Et tu, Brutus?” according to Shakespeare, but “Kal au et ekelon, kal au, teknon?” (And thou art one of them, thou, my son?” in Greek) according to Suetonius. Also note the reference to the Latin version of the Bible, the Vulgate, that is the vernacular, or vulgar, tongue, in contrast to the Greek of the leaders, including the church leaders (in the 4th century).

The Romans were not scholars, but generals and civil administrators. Thus, in the heyday of Latin literature, from a century or two before the beginning of the Christian era to an equal time afterwards, the authors found themselves with an inadequate language. This situation was especially true in science and philosophy. This was well expressed by Cicero: “We are obliged to create a vocabulary and to find names to attach to new discoveries. This will not cause surprise to any moderately well-informed person, when he reflects that in every branch of knowledge lying outside the most elementary ones there must be a large measure of ‘newness’ about its vocabulary.” Names were not difficult to find, “the Greek had a name for it”, usually two or more! The Roman authors wrote in Latin although most of them were fluent in Greek because there was no need to write in the latter language. All they knew and more had already been written. The surviving Greek literature is enormous in comparison with the Latin, a ratio of about 10 to 1. It may be noted that in spite of the mass of Greek which has been “mined” for the words of the dictionaries and lexicons there exists a great amount yet unstudied. It is estimated that approximately 20,000 papyri are stored in the archives of the museums and libraries of the world, and that only about half of them have been translated.

The study of insect name will continue. I am compiling glossaries of Latin and Greek insect names and my search for the first use as insect names of the generic names of Linnaeus will continue in the 16th and 17th century biological writings. The hunt for ancient names of dragonflies will go on as a most absorbing avocation to my odonatological studies.

THE “INSECT” GENERIC NAMES OF LINNAEUS

The list of names includes the names proposed by Linnaeus for insects (in the “Linnean sense”—approximately synonymous with arthropods) in the first (1735), tenth (1758) and twelfth (1766) editions of the Systema Naturae. Information about the names is indicated by the following symbols:
Names used in substantially the same form as those used by classical Latin and/or Greek authors for insects.

* - names appearing in glossaries of classical Latin or Greek but apparently not used in antiquity for insects.

ο - words not found in glossaries of classical Latin, although some occurred in Greek as indicated.

+ - the Linnean name is a diminutive, or other derived form, of a Latin or Greek word.

a - name used for insect by Aldrovandus, 1602.

Prefix of a serial number (170-243)-names proposed in the 10th edition (1758)

Prefix of "12)"-names proposed in the 12th edition (1766)

Suffix of "(1)" to name-names listed in the 1st edition (1735)

Each name, if known in classical Latin in approximately the same form as used by Linnaeus, is followed by reference(s) to Latin author(s) as cited in glossaries. Diminutives or other derivatives used by Linnaeus, are followed by the source word with citations. For words derived from Greek, either directly or through classical Latin authors, the Greek original is given and Greek authors are cited. In some cases (and these may be impossible to distinguish) the classical Latin and Greek words may be cognates, rather than one being derived from the other. The Latin apis appears to be cognate with the English word bee, German Biene, etc., but amūcis appears never to have been applied to an insect, but referred to the sacred bull of Egypt. Bērra was derived from Latin (one of only a few Greek words of such origin) but did not refer to an insect, meaning purple. This derivation was from an alternate Latin meaning, a clot of blood, hence, by extension, purple, the color of blood.

Gender is indicated for Greek nouns and adjectives (for which the masculine is always cited) by the familiar designations of M-masculine, F-feminine, and N-neuter, rather than by the article which is used for this purpose in Greek dictionaries, lexicons and grammars. However, gender of the original Greek may have little significance for the use of the Linnean names in nomenclature. Linnaeus, or his predecessors, in adopting the name (even ancient Greek or Latin writers) to be applied to insects may have changed the form of the word to conform to another gender.

ANNOTATED LIST OF AUTHORS
(With Abbreviations used in the List of Names)

These were selected from the ancient Greek and Latin authors from whose works words were compiled into lexicons and dictionaries of the classical languages. Works of most of these were published soon after the invention of printing. They were, thus, available to Linnaeus and the preceding 16th and 17th century writers on natural history as a source of "suitable" names for plants and animals. I have cited the authors whose works were well known and thus were the most likely sources for such names.

Ael - Aelianus, Greek author, 2nd-3rd centuries A.D.
Aes - Aeschylus Greek tragic dramatist, 525-456 B.C.
Amb - one of the Latin "church fathers," 340?-397 A.D.
Aris - Aristotle, Greek philosopher and "scientist", father of Zoology, 384-322 B.C.
Art - Aristophanes, Greek comic dramatist, 450?-380? B.C.
Cato (the Elder) - Roman orator and historian, 234-149 B.C.
Cic - Cicero, Roman statesman, orator and author, 106-43 B.C.
Col - Columella, Latin writer on husbandry, 1st century A.D.
Dsc - Dioscorides, Greek physician, author of famous herbal, 1st century A.D.
Gal - Galen, Greek physician and medical author, 130?-200? A.D.
Hdt - Herodotus, Greek historian, 5th century B.C.
Hes - Hesiod, Greek poet and bucolic writer, 8th century B.C.
Hippocrates, Greek physician, father of medicine, reputed author of extensive medical writings (and the Hippocratic oath), 460?-377? B.C.
Homer, Greek epic poet, author of the Iliad (I), ca. 750 B.C., and the Odyssey (O), ca. 720 B.C.
Horace, Roman poet, 65-8 B.C.
Hesychius, Greek lexicographer, 5th century A.D.
Isidore of Seville, Latin scholar and encyclopedist, 560?-636 A.D.
Livy, Roman historian, 59 B.C.-17 A.D.
Lucretius, Roman poet-philosopher, 96?-55 B.C.
LXX - the Septuagint, Greek translation of the Old Testament, made at Alexandria, ca. 250-100 B.C.
Nicander, Greek epic poet, 2nd century B.C.
Ovid, Roman poet, 43 B.C.-18 A.D.
Petronius, Roman satirist, ?-66 A.D.
Pindar, Greek lyric poet, 522?-433 B.C.
Pliny, Roman naturalist and encyclopedist. His Natural History in 37 volumes made him the most influential “biologist” after Aristotle. 23-79 A.D.
Plutarch, Greek biographer and essayist, 46?-120 A.D.
Sophocles, Greek tragic poet, 496-406 B.C.
Suetonius, Roman biographer and historian, 69?-140? A.D.
Theophrastus, Greek philosopher and “scientist”, successor to Aristotle, father of Botany, 372?-287? B.C.
Varro, Roman scholar and author, 116-27? B.C.
Vergil, Roman epic poet and bucolic writer, 70-19 B.C.
Vul - the Vulgate, Latin version of the Bible, first translated near the end of the 2nd century A.D.; revised (383-405 A.D.) by (and generally attributed to) St. Jerome (Sphronius Eusebius Hieronymus), 347-419 A.D.

LIST OF NAMES

235° ACARUS (1) =akaros(N) - Aris.
237° APIES (1) =aipa(M) - Hdt.
237° ARANEA (1) =arachne(F) - Aris, Hes.
227° ASILUS =papavoc(M) - Aris, Dsc, Hpp.
178° ATTETALBUS (1) =aptelesos(M) Aris, Hdt, Thph.
193° BLATTA (1) =blatta(F) (from Latin)
228° BOMBYLIUS =bomblies(M) - Aris, Dsc, Hpp.
12° BRUCHUS =bruchos(M) - LXX, Thph.
184° BUPRESTIS (1) =buprestis(F) - Aris, Dsc, Hpp.
12° BYRRHUS =byrros(M). Tyrrhenian for kandaros.
239° CANTHARIS (1) =kandaros(M) - Aris.
181° CARABUS (1) =karaMoc(M) - Aris.
174° CASSIDA (1) (Latin) =Isid, Pl, Ver.
179° CERAMBYX (1) =Cerambycidae(N) - Isid, Pl.
201° CHERMES =keramin(M) - Hsch, Nic.
12° CHRYSIS =phiuac(F) - Aqu.
176° CHRYSOMELA (1) =phiuose(F) - Art.
195° CICADA (Latin) =Luc, Pl, Ver.
183° CICINDELA (1) (Latin) =Pl.
198° CICINDELA (1) =Luc, Pl, Ver.
175° COCCINELLA (1) =Pet.
+ *kokkos(N) - Arrianus.
201° COCCUS =kokoMoc(M) - Thph.
226° CONOPS =konos(M) - Aris, Hdt.
224° CULEX (Latin) =Hor, Luc, Pl, Ver.
177° CURCULIO (1) (sometimes written as gurgulo) - Cato, Pl, Var, Ver.
+ *miyos(M) - Art.
212° CYNIPS =cynips(M) - Thph.
171° DERMETES (1) =Symos(N) - Sop.
12° DIOPSIS =diuos(F) - Plu.
185° DYTISCUS (1)
  *υρωκος(M) - Aris.
182° ELATER
  *Λαύρατο(M) - Pin.
225° EMPIS
  ς εμης(F) - Aris, Art.
209° aEPHEMERA(1)
  εφημερος(N) - Aris.
192° FORMICA(1) (Latin) - Pl.
219° aFORMICA(1) - Cic, Hor, Pl, Ver.
  =μωρα(μ) - Hes.
194° GRYLLUS (1) Pl
  *τρισλος(M) - Hsch, Pl.
  *aGRYRINUS(1) - Pl.
  *μωρικος(M) - Plato
209° aHEMEROBIUS(1) - Pl.
  εμεροβος(N) - Thph.
229° HIPPOBOSCA
  τρομοσκος(M) - Ael.
12° HISPAG
172° HISTER - Liv, Ov, Ver.
  *τιστος(M) - H(O), Aris.
214° ICHNEUMON(1) - Cic, Pl.
  =υγνος(M) - Aris, Pl.
243° aJULUS - Pl, Ov, Var.
  =ουλος(M) - Aris, Thph.
  =ΛΑΜΠΥΡΗ(1) - Pl.
  =λαμπυρις(F) - Aris
12° LATERNARIA from lanterna - Cic, Pl.
  *λαμπτερις(M) - Aris, H(O), Hpp.
230° aLIPISMA (from lepis, leptidis) - Pl.
  =απλεια(N) - Dsc, LXX, Gal.
180° aLEPTURA(1) (?from Lepta, or Lepisma)
  *λεπτος(M) - Aris, H(O), Hpp.
206° aLIBELULLA(1) (from libella, which may have been applied to dragonflies in ancient times) - Pl, Var.
  *LUCANUS(1) - Cic, Hor, Pl, Var.
  *λακνα(μ) - Aris, Plu.
188° MELOE(1)
  *ομελη(ος, or ?μηλη(ος(N).
189° aMORDELLA (from mordeo - Hor, Pl.)
  *συμπροδος(M) - Hsch.
240° aMONOCULUS(1) (Latin) μονος + occlus!
222° aMUSCA(1) - Cic, Sue, Var.
  =μωκα(μ) - Thph.
219° aMUTELLA (from mutus - Vul.)
  *μωτος(F) - Aris, Plu.
12° aMYRMELEON
  =μυρμηκολος(M) - LXX.
190° aNECYDALIS(1) - Pl.
  =νεκυδαλος(M) - Aris.
197° NEPA (Latin, from an African language source) - Cic.
196° NOTONECTA(1)
  aNOTOPEDA(1)
220° aOESTRUS - Pl, Ver.
  =οιστρος(M) - Aes, Aris, H(O).
241° aONISCUS(1) - Pl.
  =ονισκος(M) - Gal, Hsch.
210° PANORPA(1)
203° aPAPILO(1) - Pl, Ov.
  +παπλως - Hes.
12° PAUSUS
233° aPEDICULUS(1) - Pl. (Sometimes written pediculus - Pl.) ?Related to (at least referring to the same insects) = φθειρ (M, later F) and = φθειρα(ος(F) - Dsc, Hdt, Gal, Plu.
205° PHALEANA (usually written: balaena) - Ov, Pl.
  =φαλανα(μ) (usually: φαλανα) Aris, Gal, Nic.
236° PHALANGIUM - Isid, Pl, Ver.
  =φαλαγγων(N) - Aris, Thph.
208° PHRYGANA(1) - Pl.
  φρυγανων(N) - Aris, Hdt, Plu.
231° PODURA
12° PTINUS
  *πτηνος(N) - Aris, Art.
234° aPULEX(1) (Latin) - Pl.
211° aRAPHIDIA(1) (from raphanus - Cato, Col, Pl.)
  +rαφις(F) - Aris, Hpp.
170° aSCARABAeus(1) - Pl.
  =?ακαραβολος(M) - Hsch.
242° aSCOLOPENDRA(1) - Pl.
  =ακολοπενδρα(μ) - Aris, Dsc, Gal.
238° aSCORPION(1) - Ov, Pl, Vul.
  =ακορπος(M) - Aris.
173° SILPHA
  =αληφις(F) - Ael, Aris, Gal.
12° SIREX
215° aSPHIX(1) - Aris.
  =σφηξ(F) - Aris.
204° aSPHINX - Pl.
  σφηξ(F) - Ael, Hes.
191° aSTAPHYLINUS - Col, Pl.
  =σταφυλως(M) - Aris, Hsch.
223° aTABANUS (Latin) - Pl, Var.
187° TENEBRIO (Latin) - Var.
213° TENTHREDI(1)
  =τενθρεδις(μ) - Aris, Dsc.
232° TETRAS (Latin, more frequently: tarmes) - Isid, Ver.
202° aTHRIPS - Pl.
  =θρης(M) - Thph.
221° aTIPULA (Latin, as tipula) - Var.
216° aVESPA (Latin) - Pl, Var.
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