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A Preliminary Study of the Chorion Design in the Micropyle Area of Noctuid Eggs (Lepidoptera)

By H. L. Seamans

Presented April 1933 to the Faculty of Arts and Sciences of the University of Saskatchewan, in Partial Fulfillment of the Requirements for the Degree of Master of Science.
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A Preliminary Study of the Chorion Design
in the Micropyle Area of Noctuid Eggs

By H. L. Seamans

Introduction

The family Noctuidae is the largest family of the Lepidoptera and includes all those larval forms which are commonly known as "cutworms". These larvae are the generally hairless caterpillars of the heavy-bodied "owllet moths" or "millers" which are so abundant around lights on summer evenings. The name "cutworm" has been applied to the larvae because the more common forms feed on the lower stem portions of plants, cutting them off close to the soil surface.

The feeding habits of the larvae of this family are variable. Many species confine their activities to the soil, and can only be found by digging. Some species remain in the soil during the day but come up at night and climb the food plant, feeding entirely on the upper leaves. Other species are never found in the soil and remain on the food plant during their entire development.
The economic importance of some species of noctuids has resulted in extensive studies being conducted on the biology and control of the larvae. The abundance of species and the variations in the adult markings within species have complicated the systematic study of the family. The great mass of published material dealing with the Noctuidae has dealt with these phases and ignored the eggs except for occasional brief descriptions or to note that they occur in the life history.

General entomological texts frequently refer to the great variety of shapes and chorion designs which occur in insect eggs. Metcalf and Flint (17 - p.133) state "Of special usefulness is the sculpturing of the egg shell as seen under the microscope. A great variety of impressions, elevations or depressions are found, the exact shape and arrangement of which will often serve to distinguish one species from another." Illustrations of noctuid eggs are common in literature but with the exception of Henneguy (11 - p.297), Parker, Strand and Seamans (19 - p.314) and Strickland

Numbers in parenthesis refer to the bibliography.
(27 - p. 9) no detailed illustrations of the micro-
pyle area have been found. In all other cases the
chorion reticulations are shown with a more or less
blank area labelled "micropyle" in the center.
Crumb (4) has published egg descriptions which refer
particularly to the size of the egg and the number
of "ribs". He also notes the presence or absence
of "transverse lines" but usually refers to the
micropyle area as being reticulated.

Much misinformation has been published re-
garding the oviposition habits of the noctuid moths.
The general statement, "the adult moths lay their
eggs on vegetation which will be suitable for larval
food" is far from correct. Observations in the field
and experiments with caged moths show that many
noctuid species lay their eggs in bare soil whether
vegetation is present or not. Of 39 species which
have been observed ovipositing in the field or in
cages, 30 deposited eggs in the soil, even though
larval food plants were available. This indicates
that the hours which have been spent in fruitless
searching of larval food plants for eggs, have been
largely wasted and that eggs found in soil may belong to any one of a great number of species.

The present study is an attempt to illustrate and define the chorion markings surrounding the micropyle in the hope that they may be of value in determining the species to which the egg belongs. No attempt is being made to use the egg design as a basis of noctuid classification although a study of the eggs may show resemblances which would assist in definitely placing a doubtful species. This study is not concerned with the histology or function of the chorion or micropyle although some discussion as to the formation of the chorion and the source of the chorion markings is necessary.

Technique

Eggs for this study were secured in two ways, by natural oviposition in cages and by dissecting female moths. Several methods were used to secure eggs by oviposition. Live moths were confined in paper bags, tin boxes, glass tubes and screen cages but the results were not generally satisfactory.
Finally a special cage was constructed by using "Kerr Wide Mouth Mason" fruit jars as described by the writer (20). Dry soil was sifted through a 72 mesh screen wire and placed in the jar to a depth of approximately one half inch. Sprigs of vegetation were placed in the jar and absorbent cotton saturated with a weak honey solution was placed on the screen top as a food supply.

Moths were collected from sugaring, flowers, and light traps and isolated in these prepared cages. When the moths had died the soil was sifted and the eggs recovered on the screen. The vegetation and sides of the jar were also examined for eggs.

Some species could not be induced to lay under any conditions, and others were not collected except in a regular light trap equipped with a killing jar. These moths were preserved in 70 per cent alcohol for dissection. Only the fully developed eggs were used and in many cases none of the specimens contained eggs sufficiently mature to warrant slides being made.
The eggs which were secured were carefully broken and that part of the chorion containing the micropyle was separated from the rest of the shell. This small portion was cleared with clove oil and mounted directly in Canada balsam. No attempt was made to stain the chorion since it was noticed that the ridges forming the markings stood out quite clearly in transmitted light.

The drawings were made with a camera-lucida. Those of whole eggs were made by using a No. 5 ocular and 16 mm. objective. In these drawings the scale of magnification is shown by a hair line representing 0.5 mm. The greatly enlarged drawings of the micropyle areas, follicle designs and chorion designs were made by using the higher powered 4 mm. objective. The magnification for these, is shown by a hair line representing 10 microns.

All illustrations of the chorion design have been made in pairs. One of these is a plain line drawing to show the position of the ridges. These lines follow the middle line of each ridge.
and show the main features of the entire design. The other is a line drawing which outlines the actual smooth areas of the chorion. This does not show the main features of the design so clearly but is necessary to give the comparative width of the ridges on different portions of the same egg or different eggs.

Variations in Eggs and Micropyle Areas

The eggs of Noctuids are either spherical, sub-spherical or hemi-spherical. Some are very slightly pear-shaped and practically all are at least a little flattened at the pole opposite the micropyle. In the oviducts and ovules the eggs are packed together so that both poles are flattened with the micropyle located at the posterior pole.

During oviposition the egg is turned and placed with the micropyle at the top.

The majority of noctuid eggs have no covering other than the chorion although there is usually a sticky secretion deposited with them which cements them to the support or causes particles
of soil to adhere to them. Such an egg is represented by Graphiphora collaris G. & R. (Fig. 1.). The egg of Ipimorpha subvexa Grt. has what appears to be a thick, waxy outer covering over the chorion. This egg, (Fig. 1.), appears pure white at all times, and under a binocular microscope, seems to be composed of a series of overlapping ridges formed by white threads. The micropyle appears set in a deep crater. The ridges leading out from it are very broad and directed upward along the sides of the crater. After treatment with clove oil this outer covering becomes transparent and the true chorion can be easily seen through it.

The micropyle area varies in cross section as shown in Figure 1. In several species this entire area is raised as illustrated by G. collaris (Fig. 1.). An extreme case of the raised micropyle area is represented by I. subvexa, (Fig. 1.). This example is very unusual for while the area is raised above the chorion, the micropyle is actually located in a deep crater owing to the thick covering over the chorion. One of the most common forms of the
Fig. 1 Variations in Eggs and Micropyle areas.
micropyle area is illustrated by *Feltia ducens* Wlk. (Fig. 1.). In this species there appears to be no variation in the curvature of the egg surface except for the slight indentation at the actual micropyle opening. The examination of eggs of several species indicates that the micropyle area may be raised, flat or depressed, with *A. collaris* at one limit and *I. subvexa* at the other.

**Development of the Chorion and Chorion Design**

The eggs of noctuids are formed and developed in the ovules and pass through to the oviduct which they reach when fully developed. As the eggs form in the ovules, invaginations occur between them and eventually each is enclosed in an epithelial sac or egg follicle. (Fig. 2). This follicle passes down the tube with the egg as a food chamber. As the egg ripens the follicle disappears.
Fig. 2  Development of the Chorion Design in Trachea cinetacta Grt.
A. chorion design. B, C and D, corresponding egg size, follicle
design and follicle disposition.
Writers generally agree that the chorion is secreted on the inner surface of the follicle by the epithelial cells. The ridges and pits forming the chorion design are due to the impress of these cells.

Eggs in different stages of growth have been dissected from the ovules and carefully examined. The first evidence of any exterior design appears as soon as distinct follicles are formed. This starts with indistinct lines radiating from the micropyle end of the follicle and extending part way towards the opposite pole. As the eggs increase in size (Fig. 2) cross lines appear, dividing the surface of the follicle into distinct areas. At this time the chorion is very thin and shows no distinct markings.

As growth continues, the areas between the lines on the follicle seem to stretch and expand without any appreciable widening of the lines separating them. The chorion becomes thicker, and a distinct design in the neighborhood of the micropyle appears. This is marked by indistinct lines while the spaces between appear granular. With
most species this granular structure gradually disappears leaving the chorion with distinct ridges and translucent spaces between them.

None of the eggs examined showed a distinct micropyle design on the follicle. This area shows very indistinct lines radiating out from a common center. These lines appear of varying lengths and end indistinctly in the main granular substance. In no case were any connecting lines visible even when this design was distinct on the chorion.

In all species studied the ridges radiating from the micropyle are quite distinct. Beyond that area they may become broader and heavier or dwindle away entirely. In the former case the egg presents a distinctly ribbed appearance from the micropyle to the base. Species with less distinct ridges present a smooth or faintly reticulate appearance on the lower half.
The Design of the Micropyle Area

The micropyle is an opening in the chorion of the egg which allows the spermatozoa to pass through for fertilization. For the purposes of this study the micropyle area is considered as that portion of the chorion which has the micropyle as a center and approximately one sixth of the egg diameter as a radius. Only a portion of this area is shown in each illustration.

When examined under the microscope with transmitted light, this area greatly resembles a cellular structure. Because of this resemblance, the terms "cells" and "cell walls" are used in referring to the spaces and ridges. This use of these terms is obviously incorrect but no others have been found which are so simple and adequate. The "ribs" mentioned by Crumb (4) are ridges or "cell walls" converging on the micropyle, while the "transverse lines" are the cell walls connecting the ribs.

The typical design of this area consists of several series of cells. These are described as follows:

1. **Primary cells**, radiating from the micropyle are fairly regular in size and shape but vary in numbers. These cells are pointed at the micropyle end and broaden at
the other, forming a circular area.

2. Secondary cells form a more or less regular circle of cells concentric with the primary circle but varying greatly in length and shape in different species.

3. Tertiary cells are missing in some species but often present as a third circle of regular or irregular cells.

4. Quaternary cells are rare, but when present form a fourth concentric circle of fairly regular cells.

5. Polygonal cells are the cells which form the major part of the chorion design. These cells usually increase in size as the greatest diameter of the egg is reached but are prevented from becoming too large by the intervention of accessory cell walls or ribs.

6. Accessory cells are very small and of two kinds:

   a. Angle cells occur in the angle formed by the junction of the cell walls of the polygonal cells. In some species these cells are round and in others they are triangular. These cells can be found in several species far outside the micropyle area and then only with difficulty. Luperina passer (Fig. 22 A) is an example of this type and for purposes of classification is considered as having no accessory cells.
b. Rib cells occur at any point along the main longitudinal cell walls and may give these walls a chain-like appearance. In some species they appear as punctures in an exceptionally wide longitudinal wall.

In some species the angle cells appear to be tubercles which bear a very tiny hair. It is possible that a more detailed study of the chorion may reveal these structures as actual openings. It is evident that there is a passage of moisture through the chorion during embryonic development which can hardly be accounted for by the micropyle alone. This would indicate a certain degree of porosity of the chorion. Some accessory cells show no sign of either tubercles or hairs while hairs or spines are occasionally present when accessory cells are absent.

Classification of the Noctuidae

The classification of the noctuids is apparently very unsettled. The most recent work by McDunnough (16) concerns Agrotid genera comprising the Agrotes group as outlined by Smith but not the entire Agrotinae
of Hampson. In this work and in an article preceding it (15) McDunnough uses genetical characters for placing the genera and species in the sub-family. Some new genera are described to receive species which cannot be otherwise placed, and several old generic names are revived to receive other species.

The most complete work on noctuids was published by Hampson (10) and his classification was followed for North American species by Barnes and McDunnough (1). Except where genera have been changed by McDunnough’s recent publications (15 & 16) the arrangement of the illustrations follows the specific arrangement of Barnes and McDunnough. (1).

According to this check list there are thirteen sub-families, listed as follows:

1. Agrotinae
2. Hadeninae
3. Cuculliinae
4. Acronyctinae
5. Erastiinae
6. Euteliinae
7. Sarrothripinae
8. Catocalinae
9. Pantheinae
10. Phasiinae
11. Erebinæ
12. Hyponinae
13. Hyblaeinae
The eggs of fifty species occurring in six of the above sub-families have been studied, and the design of the micropyle area illustrated. From an examination of these illustrations it will be seen that the eggs fall into more or less definite groups which do not correspond to the sub-families of genera as at present arranged for the adults. Fracker (8) in his study of the noctuid larvae experienced the same difficulty. He found that the larvae could be divided into four distinct groups, none of which corresponded in any way with the present sub-family classification.

Grote (9) placed many of these species in the genus Agrotis. This was an all embracing genus which included many species now placed in Euxoa. The sub-families as outlined in this work do not in any way correspond to the groupings of the egg designs.

It is possible that future work with stable adult characters may result in a definite and final placing of species into genera and sub-families, and further study of the eggs and larvae may reveal new characters for determination which will enable them to be brought into the same groups as the adults.
For the present study a relationship of the eggs must be worked out independent of larval or adult characters.

Eggs of species under the present sub-family classification have been studied as follows:

**Agrotinae**

a. Heliothis group 1 Genus, 1 Species.
b. Agrotis group 10 Genera, 23 "

**Hadeninae**

7 " 10 "

**Culculllinae**

2 " 2 "

**Acronyctinae**

11 " 11 "

**Catocalinae**

2 " 2 "

**Piloisinae**

1 Genus 1 "

**Total.** 34 Genera 50 species

The Grouping of Species by Markings of the Micropyle Area of the Eggs

The different series of cells which comprise the design of the micropyle area show marked similarities existing among the species studied. These similarities place the eggs in fairly definite groups which do not correspond to the sub-families or genera in which the adults have been placed. The study of
several different eggs from one individual as well as those from several individuals of the same species indicates that the arrangement and shape of these cells are fairly constant. The number of primary cells may vary one or two in a single species but in no case have they been found to vary more than two. The placing of the species of eggs into groups follows what seems to be a natural arrangement leading from the immature egg to a complex and regular design.

The chorion of the immature egg (Fig. 2) has irregular primary cells and the walls of the secondaries appear only as cleared lines between granular areas. The mature eggs of the majority of species have regular primary cells evenly rounded at the outer ends, and well developed cell walls in the secondaries. The primary cells form a regular circular area around the micropyle and the secondaries a more or less concentric area outside of them. These which do not conform to these characteristics have been placed in groups which seem to connect the immature egg with the design of the mature chorion in the majority of species.
Group 1, includes *Barathra configurata* Wlk. (Fig. 15 A), *Homohadena infixa* Wlk. (Fig. 19 B), *Amphipyra flabella* Morr. (Fig. 20 B), *Caenurgia erechtea* Gram. (Fig. 26 A), *Scotogramma trifolii* Rott. (Fig. 15 B) and *Ipimorpha subvexa* Grt. (Fig. 21 B).

The first four of these species have very irregular primary and secondary cells which are more or less confused. *S. trifolii* has regular primary cells but the secondaries appear somewhat granular with evanescent walls. The primary cells of *I. subvexa* are regular but distinctly pointed at the outer ends while the secondaries are very irregular with distinct cell walls. This species appears to be a connecting link with the following groups but is placed here because of the pointed primary cells.

The following groups all have normal primary cells and are divided on the basis of the uniformity of secondary and tertiary cells, and to some extent on the shape of the polygonal cells. The species are arranged so that a gradation occurs throughout the group, bringing closely related designs together. In this way the first and last species listed in each group resemble the preceding or following groups more closely than they do each other.
Group 2, is closely associated with A. subvexa by Abagrotis placida Grt. (Fig. 14 B). The secondary cells are more regular than any species in group 1 and the tertiaries are very irregular. These irregularities gradually become less when proceeding through Polia columbia Sm. (Fig. 15 C), Athetis extima Wlk. (Fig. 23 A), Pseudospauleotis haruspica Grt. (Fig. 12 B), Paradiasia littoralis Pack. (Fig. 12 A), Neuria procingta Grt. (Fig. 17 B), Polia renigera Steph. (Fig. 17 A), P. vicina Grt. (Fig. 16 B) and Sideridis rosea Harv. (Fig. 19 A). P. renigera and S. rosea might be placed in a special group reserved for species containing accessory cells. The general appearance and characters place these species in this group and as the accessory cells appear as minute punctures in broad rib walls, these two species would constitute a group by themselves. The more even secondary cells of S. rosea could place this species in the next group but it is placed here because of its general similarity to P. renigera.

Group 3 contains those species which show more uniformity in length or size of the secondary cells and an approaching uniformity of the tertiary cells. The polygonal cells in this group also become
more uniform. *Oligia egens* Wlk. (Fig. 21 A) is placed first in this group because of its general resemblance to the preceding species although the tertiaries are fairly uniform. This species is followed by, *Euaegrotis tepperi* Sm. (Fig. 11 B), *Graphiphora conigrum* L. (Fig. 13 A), *G. smithii* Snell (Fig. 13 B), *G. collaris* G. & R. (Fig. 14 A), *Agrotis vetusta* Wlk. (Fig. 8 B), *Eurcis occulta* L. (Fig. 11 A), *Euxoa scandens* niley (Fig. 6 A), *Apamaea nictitans* L. (Fig. 23 B), *Hyssia orbiculata* Sm. (Fig. 18 A), *Agrotis venerabilis* Wlk. (Fig. 9 B) and *A. orthogonia* Morr. (Fig. 9 A). The last two species have accessory cells but their general characters place them distinctly in this group. The presence of only angle cells in *A. orthogonia* relates this species remotely to the Euxoas which comprise the greater part of the following group.

Group 4 contains species with angle cells. Their uniform secondary cells relate them to the previous group but they are separated by the generally small and uniform polygonal cells. *Euxoa messoria* Harris (Fig. 6 B) most closely resembles *A. orthogonia*. The uniformity of the series of cells increases through
E. albipennis Grt. (Fig. 7 A), E. basalis Grt. (Fig. 7 B),
E. ochrogaster Gn. (Fig. 8 A), E. flavicollis Sm.
(Fig. 5 B), E. ridingsiana Grt. (Fig. 5 A), Parastichites
puta G. & R. (Fig. 20 A), Euxoa plagigera Morr. (Fig. 4 B)
Polia radix Wlk. (Fig. 16 A), Euxoa dargo Stkr. (Fig. 3 E)
and E. quadridentata G. & R. (Fig. 4 A). All the Euxoas
studied are quite similar with the exception of E.
scandens which fits into group 3 and cannot be placed
in this group by any stretch of the imagination. In
addition to the Euxoas, P. puta and P. radix undoubtedly
fit in this group better than in any other.

Group 5 contains a series of species which
form a transition from the design of the Euxoas to the
very uniform and more or less "rosette" design which
occurs in group 6. Luperina passer Gn. (Fig. 22 A)
resembles E. quadridentata and group 4, by having
minute angle cells remote from the micropyle. For
all practical purposes in a key these cells are con­
sidered as missing because of their minute size and
position. The fact that they are actually present
in the design is more uniform than the Euxoas places
this species as the connection between groups 4
and 5. Feltia ducens Wlk (Fig. 10 A) closely re­
sembles the Euxoa as but has no angle cells and the general appearance of the design approaches a series of circles concentric with the micropyle. This concentric appearance becomes more marked through, Copablepharon longipennis Grt. (Fig. 3 A), Gortyna pallescens Sm. (Fig. 24 A), Sidemia devastator Brace (Fig. 21 B), Nephelodes tertialis Sm. (Fig. 18 B) and Catocala orion McD. (Fig. 25 B). This last species has the most regular and uniform cells of any that were studied.

Group 6 is composed of species which have a design that appears very regular. This appearance is not due to the uniform shape and size of the cells beyond the primaries, but to the fact that they all seem to come out from a common center. This center is the micropyle and the entire design appears as a complex rosette. The species in this group most closely resembling C. orion, is Autographa falcifera Xby (Fig. 26 B). The cells for some distance out from the micropyle are very regular and while they do not
form the typical rosette design it is nearer it than is C. orion. *Protogrotis niveivenosa* Grt. (Fig. 22 B) approaches the true rosette design by having the secondary and tertiary cells rounded instead of flattened as in *A. falcifer*. The true rosette begins to take form in *Trachea cinefacta* Grt. (Fig. 20 C) and through *Stiria rugifrons* Grt. (Fig. 25 A) reaches the most perfect design of this type in *Spaelotis clandestina* Harr. (Fig. 10 B).

From this study of the designs it is evident that the eggs fall into six fairly distinct groups which progress gradually from the design of the immature chorion to a complex rosette. This arrangement and the adult sub-family groupings for these species are shown in the following list.

Group 1. *Barathra - Ipimorpha* group.

1. *Barathra configurata*  
   Hadeninae.
2. *Homohadena infixa*  
3. *Amphipyra glabella*  
4. *Caenurgia erchthia*  
5. *Scotogramma trifolii*  
6. *Ipimorpha subvexa*  
   Acronyctinae
Group 2. **Abagrotis - Sideridis** group.

1. *Abagrotis placida*  
   *Agrotinae*  
2. *Polia columbia*  
   *Hadeninae*  
3. *Athetis extima*  
   *Acronyctinae*  
4. *Pseudospaelotis haruspica*  
   *Agrotinae*  
5. *Paradiarsia littoralis*  
   "  
6. *Neuria procincta*  
   *Hadeninae*  
7. *Polia renigera*  
   "  
8. *P. vicina*  
   "  
9. *Sideridis rosea*  
   "

Group 3. **Oligia - orthogonia** group.

1. *Oligia egens*  
   *Acronyctinae*  
2. *Eusagrotis tepperi*  
   *Agrotinae*  
3. *Graphiphara c-nigrum*  
   "  
4. *G. smithii*  
   "  
5. *G. collaris*  
   "  
6. *Agrotis vetusta*  
   "  
7. *Eurois occulta*  
   "  
8. *Euxoa scandens*  
   "  
9. *Apamaca nictitans*  
   *Acronyctinae*  
10. *Hyssia orbiculata*  
    *Hadeninae*  
11. *Agrotis venerabilis*  
    *Agrotinae*  
12. *A. orthogonia*  
    "
Group 4. _Euxoa_ group.

1. _Euxoa messoria_  
   **Agrotinae**

2. _E. albipennis_  
   **"**

3. _E. basalis_  
   **"**

4. _E. ochrogaster_  
   **"**

5. _E. flavicollis_  
   **"**

6. _E. ridingsiana_  
   **"**

7. _Parastichites puta_  
   **Hadeninae**

8. _Euxoa plagigera_  
   **Agrotinae**

9. _Polia radix_  
   **Hadeninae**

10. _Euxoa dargo_  
    **Agrotinae**

11. _E. quadridentata_  
    **"**

Group 5. _Luperina - Catocala_ group.

1. _Luperina passer_  
   **Acronyctinae**

2. _Eltia ducens_  
   **Agrotinae**

3. _Copablepharon longipennis_  
   **"**

4. _Gortyna pallescens_  
   **Acronyctinae**

5. _Sidemia devastator_  
   **"**

6. _Nepheleodes tertialis_  
   **Hadeninae**

7. _Catocala orion_  
   **Catocalinae**
Group 6. Rosette group

1. Autographa falcifera  
   Plusiinae

2. Protogrotis niveivenosa  
   Acronyctinae

3. Trachea cinefacta
   "

4. Stiria rugifrons
   "

5. Spaelotis clandestina  
   Agrotinae.

The relationship of species as shown by this list is interesting when viewed in the light of the many places to which species have been shuffled in past classifications of adults. No attempt is being made here to review these changes or suggest that the present classification is at fault. A more detailed study which includes a greater number of species may require an entirely different grouping although it is possible that additional species will fall into these six groups without alteration.
The Determination of Species by a Study of the Egg Design

A careful study of the egg designs in the micropyle area shows that they possess characters of specific value. These characters have been used in drawing up a key to the fifty species studied. To one not familiar with the markings of noctuid eggs there may be a few points which are not clear. These can be overcome by referring to the illustrations and the definitions of the various cells and areas.
Key to the Eggs of the Species Studied.

1. Primary cells very uneven, irregular or distinctly angular at the outer end................2
   Primary cells regular and rounded at the outer end.............................................6

2. Entire egg covered with a thick, white outer coating and the micropyle set in a deep crater in this coating. Primary cells distinctly pointed at the outer end and fairly uniform. Primary cell walls not uniform and very thick.
   Ipimorpha subvexa Grt. Acronyxinae (Fig. 24B)
   Egg not covered with outer coating, primary cells rounded.................................3

3. Secondary and tertiary cells not easily separated and not regular or uniform..............4
   Secondary cells easily separated from tertiary or polygonal cells. Cell walls beyond the primaries serpentine instead of straight but of fairly uniform thickness. Secondary cells irregularly pentagonal.
   Amphipyra glabella Morr. Acronyxinae (Fig. 20B)

4. Cell walls very thin around the primaries and secondaries, polygonal cells some distance from the micropyle regular, pentagonal with straight, broad walls and a distinct spine at each angle.
   Barathra configurata Wlk. Hadeninae (Fig. 15A)
   Cell walls more conspicuous, no distinct spines present.....................................5

5. Primary cells mostly rounded, secondary and tertiary cells confused but not appreciably longer than the primaries. Polygonal cells long and narrow with walls appreciably thicker than those of the primaries.
   Homohadena infixa Wlk. Cuculliinae (Fig. 19B)
   Primary cells longer than wide, secondaries and tertiaries longer than the primaries and somewhat angular, though the angles rounded. Polygonal cells as wide as they are long with cell walls the same width as those of the primaries.
   Caenurgia erechtea Cram. Catocalinae (Fig. 26A)
6. Accessory cells present ........................................... 7
   Accessory cells absent ........................................... 14

7. Angle cells only present ........................................... 8
   Rib cells present ................................................. 12

8. Angle cells present on the outer end of the secondary cells and at the junction of all polygonal cell walls.
   Parastictes puta W. & R Hadeninae (Fig. 20A)
   No angle cells on the secondaries ......................... 9

9. At least twenty primary cells present. Secondary cells long and narrow and not easily separated from the tertiaries. Polygonal cells short and broad without appreciable thickening of the cell walls. Angle cells very small.
   Polia radix Wlk. Hadeninae (Fig. 16A)
   Less than twenty primary cells ......................... 10

10. Both the secondary and tertiary cells uniform and distinct. First polygonal cells sufficiently uniform to be quaternary cells. Angle cells begin at the outer margin of the second row of polygonal cells.
   Agrotis orthogonia Morr. Agrotinae (Fig. 9A)
   Both the secondary and tertiary cells not distinct and uniform or the angle cells starting at the outer border of the first polygonal cells ......................... 11

11. Angle cells present as punctures in a very broad rib wall. Secondary cells much longer than the primaries and irregular .................. 13
    Angle cells very distinct or the polygonal cell walls much thinner than those of the primaries and secondaries ......................... 12
    Euxoa spp. (Except scandens) (Figs. 3B to 8A)
12. Both the secondary and tertiary cells uniform. Rib cells abundant so that cell walls appear chain-like. Polygonal cells rectangular and broader than they are long.

*Agrotis* venerabilis Wlk. Agrotinae (Fig. 9B)

At least one series of cells not regular and uniform........................................13

13. Secondary cells of fairly uniform length but not regular. Tertiary cells very broad and irregular, extending over the ends of more than two secondaries.

*Sideridis* rosea Harv. Hadeninae (Fig. 19A)

Secondary cells very irregular, some of them shorter than the primaries. Tertiary cells covering the ends of only one or two of the secondaries.

*Polia* renigera Steph. Hadeninae (Fig. 17A)

14. Walls of secondary cells not sharply defined, particularly at the outer ends but appear as clear spaces between irregular wrinkleings of the chorion.

*ScotoGramma* trifolii Rott. Hadeninae (Fig. 15B)

Walls of secondary cells clearly defined and intervening chorion not abnormally wrinkled........................15

15. At least the secondary cells of a shape very similar to the primaries.....................16

Secondary cells markedly different from the primaries.........................................19

16. Both secondary and tertiary cells similar in shape to the primaries......................17

Only the secondary cells markedly similar to the primaries, rounded and tapering......18
17. Both secondary and tertiary cells rounded, elongate and tapering. Quaternary cells fairly distinct and rounded, the entire series forming a complex rosette with the micropyle in the center.

*Spaelotis clandestina* Harr. Agrotnae (Fig. 10B)
Less than 10 primary cells present, both primaries and secondaries flatly rounded at the outer end; tertiary cells more rounded but short and broad.

*Autographa falcifera*, Plusiinae (Fig. 26B)

18. Secondary cells of fairly uniform length and forming a complete circle distinct from the irregular secondaries. Polygonal cells irregularly hexagonal and about as broad as long.

*Trachea cinefacta* Grt. Acroynctinae (Fig. 20C)
Secondary cells of various lengths, some extending as far out from the primaries as the outer end of the irregular tertiary cells. Polygonal cells much longer than broad.

*Storia rugifrons* Grt. Acroynctinae (Fig. 25A)

19. Primary, secondary and tertiary cells very regular forming three, distinct, concentric circles. Quaternary cells irregular and polygonal cells short and broad, rectangular.

*Catocala orion* McD. Catocalinae (Fig. 25B)
At least the tertiary cells are of different lengths and shapes..........................20

20. Secondary cells extremely variable, differing from each other in shape, size and length...21
Secondary cells fairly uniform, not showing extreme variations in length, size and shape..........................30

21. The majority of the secondary cells distinctly shorter than the primaries.................22
The majority of the secondary cells at least as long as the primaries....................24
22. The secondary cells separate and distinct, each one reaching a tertiary cell. Some of the secondary cells overlapping the others and cutting them off from the tertiaries. Tertiary cells extremely irregular and somewhat merged with the polygonal cells. *Graphiphora o-nigrum* L. Agrotinae (Fig. 13A)

23. Polygonal cells of various shapes, mostly four sided and broader than long. *Athetis extima* Wlk. Acronyctinae (Fig. 23A) Polygonal cells fairly regular, hexagonal, longer than broad. *relia ducens* Wlk. Agrotinae (Fig. 10A)

24. The majority of the secondary cells distinctly longer than the primaries, practically none shorter. The secondaries of approximately the same length as the primaries, several much shorter.

25. About one third of the secondary cells approximately the same length as the primaries. Tertiary cells of various shapes and lengths, most of them longer than broad and connecting with polygonal cells which are wider than long. *Eurois occulta* L. Agrotinae (Fig. 11A) Only four or five secondary cells as short as the primaries, the rest much longer.

26. The majority of the secondary cells long, narrow and pointed at the outer end. Tertiary cells short and connecting with polygonal cells which are small and about as long as broad. *Buxoa scandens* Riley. Agrotinae (Fig. 6A) Some of the secondary cells are pointed and narrow while the rest are broad and flat at the outer ends.
27. All of the secondary cells reach the tertiaries, none of the longer ones overlapping the shorter. Tertiary cells very irregular and connecting with very broad, short, roughly four sided polygonal cells.

_Euagrotis tepperi_ Sm. Agrotinae (Fig. 11B)

Some of the long secondaries overlap the shorter ones.......................... 28

28. Tertiary cells irregular, connecting with short, broad, four sided polygonal cells. Some of the tertiaries almost as large as the entire primary cell area.

_Oligia egens._ Wlk. Acronyctinae (Fig. 21A)

Tertiary cells distinctly smaller than the primary cell region connecting with small polygonal cells.

_Polia vicina_ Grt. Hadeninae. (Fig. 16B)

29. The majority of the secondary cells pointed at the outer ends and the tertiaries sharply tapering at one end, the opposite end flattened or rounded. Polygonal cells "staggered" so that transverse cell walls do not meet at the ribs.

_Agrotis vetusta_ Wlk. Agrotinae (Fig. 8)

The majority of the secondary cells rounded at the outer end; tertiaries of various shapes; polygonal cells meeting so that transverse cell walls form fairly straight lines at their junction with the ribs.

_Abagrotis placida_ Grt. Agrotinae (Fig. 14B)

30. Secondary cells distinctly shorter than the primaries.......................... 31

Secondary cells as long or longer than the primaries................................. 32

31. Secondary cells short, broad, rounded at the outer ends; tertiary cells for the most part similar in shape and size to the secondaries. Polygonal cells about equal in width and length, roughly four or five sided.

_Protagrotis niveivenosa_ Grt. Acronyctinae (Fig. 22B)
Secondary cells distinctly angular, tertiary cells hexagonal, polygonal cells practically square.

Nepheleodes tertialis Sm. Hadeninae. (Fig. 18B)

32. Secondary cells about the same length as the primaries....................................................33
   Secondary cells distinctly longer than the primaries..........................................................38

33. Secondary cells fairly uniform in length, slender and distinctly pointed.........................34
   Secondary cells uniform, rounded or roundly angular and broad for their length..............36

34. Tertiary cells of all shapes and sizes, polygonal cells short and very broad with broad cell walls.
   Polia columbia Sm. Hadeninae (Fig. 15C)
   Tertiary cells five and six sided, generally longer than broad......................................35

35. Polygonal cells longer than broad, rib walls curving to form irregular five and six-sided cells.
   Luperina passer Gm. Acronyctinae (Fig. 22A)
   Polygonal cells broader than long, roughly rectangular.
   Apamea nictitans L. Acronyctinae (Fig. 23B)

36. Secondary cells rounded, tertiary cells about as broad as long, polygonal cells irregular, five and six-sided, some very angular four-sided.
   Gortyna pallescens Sm. Acronyctinae (Fig. 24A)
   Secondary cells roundly angular..........................................................37

37. Tertiary cells distinctly longer than broad; hexagonal; polygonal cells large, generally longer than broad and five or six sided.
   Copablepharon longipennis Grt. Agrotinae (Fig. 3A)
Tertiary cells equilateral; hexagonal; polygonal cells about the same size and shape as the tertiaries.

**Sidemia devastator** Bréate. Acronyctinae (Fig. 21B)

38. Secondary cells almost twice as long as the primaries and sharply pointed..................39
Secondary cells not so long and rounded pointed.................................................40

39. Secondary cells very broad; tertiaries fairly uniform, and almost as large as the primary cell area; polygonal cells irregular and generally broader than long.

**Graphiphora smithii** Snell. Agrotinae (Fig. 13B)
Secondary cells very narrow; tertiaries very irregular, polygonal cells fairly regular and twice as broad as long.

**Graphiphora collaris** G.&R. Agrotinae (Fig. 14A)

40. Several of the secondary cells pointed, the rest rounded or roundly pointed.............41
Secondary cells generally rounded.................................42

41. Cell walls at the ends of the primary cells much thicker than at any other point. Only an occasional triangular tertiary cell connecting the secondaries with the polygonals. The majority of the polygonal cells not much broader than long.

**Paradiarsia littoralis** Pack. Agrotinae (Fig. 12A)
Primary cell walls uniform throughout, tertiary cells irregular but definitely connecting the secondaries with the polygonals; the majority of the polygonals much broader than long.

**Pseudospaelotis haruspica** Grt. Agrotinae (Fig. 12B)
42. Tertiary cells distinctly rounded, connecting with small rectangular, fairly uniform polygonals.
   *Hyssia orbiculata* Sm. Hadeninae (Fig. 18A)

Tertiary cells irregular, very broad and short, extending over the ends of two or three secondaries. Polygonal cells large and irregular.
   *Neuria procincta* Grt. Hadeninae (Fig. 17B)

In the preceding key, the *Ruxoras* with the exception of *E. scandens* Riley, fall into one group. As there are nine species in this group a special key is presented for them.
Key to the Eggs of Euxoa spp

1. Angle cells large and very conspicuous............ 2
   Angle cells small........................................ 3

2. Secondary cells fairly uniform and pointed,
   the majority of them as long or longer
   than the primary cells.
   E. flavicollis Sm. (Fig. 5B)
   Secondary cells irregular, many of them dis-
   tinctly shorter than the primaries, some
   pointed and some rounded.
   E. ochrogaster Gn. (Fig. 8A)

3. Secondary cells fairly uniform in length and
   shape......................................................... 4
   Secondary cells of distinctly different
   lengths and shapes....................................... 7

4. Secondary cells distinctly pointed at the
   outer ends and only one or two with two
   outer angles............................................... 5
   Secondary cells rounded on the outer end or
   with several having more than one outer
   angle........................................................ 6

5. Secondary cells all distinctly longer than
   the primaries, tertiary cells very
   irregular, most of them as broad as they
   are long, polygonal cells four-sided,
   short and broad.
   E. albipennis Gnt. (Fig. 7A)
   Several of the secondary cells not distinctly
   longer than the primaries, a few shorter,
   tertiary cells long and narrow, fairly
   uniform; polygonal cells hexagonal and
   about as broad as they are long.
   E. plagipera Morr. (Fig. 4B)
6. Most of the secondary cells fairly broad and rounded at the outer ends or roundly pointed. Polygonal cells fairly large and walls much thinner than those of the secondaries.
   *E. dargo* Stkr. (Fig. 3B)
   Secondary cells of varying widths, some flatly rounded at the outer ends others with one or two outer angles. Polygonal cells uniformly small, hexagonal, with walls the same thickness as those of the secondaries.
   *E. ridingsiana* Grt. (Fig. 5A)

7. Angle cells present at the outer end of the tertiary cells..............................8
   Angle cells not present until the first polygonal cells are reached. Polygonal cells long and narrow.
   *E. quadridentata* G.&R. (Fig. 4A)

8. Secondary cells broad, short and with variously shaped outer ends; polygonal cells large and with walls equal to those of the secondaries, angle cells conspicuous.
   *E. messoria* Harris (Fig. 6B)
   Secondary cells narrow, of varying lengths and endings, polygonal cell walls very fine and angle cells minute.
   *E. basalis* Grt. (Fig. 7B)
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Conclusions

The chorion of fully developed eggs of Noctuidae show distinct markings in the micropyle area. These markings form various designs which are constant for each species and can be used for specific determinations.

The chorion design is formed by ridges which more or less radiate outward from the micropyle. In transmitted light these ridges surround clear or translucent areas of the chorion and greatly resemble a normal cellular structure. For this reason the ridges have been called "cell walls" and the spaces of chorion between them have been called "cells".

The cells occur in rather definite groups starting at the micropyle. In a diagram of the micropyle area there would be a series of cells which start at the micropyle opening and broaden out to form a circular area. These are the "primary cells". Outside of these there are concentric circular areas, the "secondary", "tertiary"
and occasionally "quaternary" cells. Beyond these, are the main cells of the chorion or the "polygonal cells". "Accessory cells" are present in some species.

The eggs of fifty species of noctuids have been studied and the design of the micropyle area illustrated. These species have been divided by the relationships shown in the designs into six groups, these starting with forms similar in the design on the immature chorion and proceeding through a gradation of designs leading up to a complex rosette form. These groups do not in any way coincide with the present sub-families into which the species have been placed by the systematic study of the adults.

The characters making up the design of the micropyle area are sufficiently distinct to be used in making a key for the determination of the species to which the egg belongs, and such a key is included.
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