COMMUNICATIONS

Some Observations on the Endocrine Systems in the Embryos of the Gregarious And Solitary Phases of Schistocerca Gregaria (Forsk.) (Orthoptera: Acrididae) I - The Ventral Head Glands*

by

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Some Observations on the Endocrine Systems in the Embryos of the Gregarious And Solitary Phases of Schistocerca Gregaria (Forsk.) (Orthoptera: Acrididae) I - The Ventral Head Glands*

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The ventral head glands of the embryos of the gregarious and solitary phases of *gregaria* were examined histologically.

1. They originate as paired invaginations from the epidermis just anterior to and either side of the second maxillary segment in both phases just after revolution. They are located in a dorso-lateral position posterior to the dorsally situated primary head muscles and they curve downwards and backwards to a rejoin of the epidermis at a point opposite the sub-oesophageal ganglion.

2. The structure of the cytoplasm is syncytial and contains deeply staining nuclei of varying shape and size. It is supplied with tracheoles. At the active stage the nuclei become lobulated and increase their size, the cytoplasm shows vacuolation.

3. Two stages of periodic activity occur thoughout the embryonic stages. The first maximum of activity in the ventral head glands coincide with retraction of the epidermiş the cuticle. The second is at the formation of melanin.

4. The volume of the ventral head glands of the embryo of the solitary phase of S. *gregaria* seems smaller than those of the embryo of the gregarious phase. This suggests a relationship to their smaller body size more than to phase characters in the embryo.

5. relationship of the ventral head glands to green pignmentation in the very early hatchlings is not clear.

INTRODUCTION

Since FUKUDA [10, 11] showed the importance of the prothoracic glands in the moulting and metamorphosis of *Bombyx mori*, the attention of many research workers was attracted to examining the endocrine centres of different insect groups.

In recent years, it has become increasingly evident that insect metamorphosis and some physiological processes (development, colour change etc.) and also behaviour, are under the control of a collection of factors generally suggested to be hormonal in character.

Something of the thoracic glands of insects has been known since 1762 at which date LYONET showed "granulated vessels" of a caterpillar's thorax and described their innervation and tracheation. He did not mention anything about their function. This description was soon forgotten until TOYAMA [44], who described the "hypostigmatic gland" in a paper on the embryology of the silkworm in 1902, and suggested it to be a glandular organ from "the stucture of the nucleus". The matter was again buried among literature on insect anatomy until the twentieth century.

Meanwhile the same organs were rediscovered and were being studied by various investigators. KE [23], used the term prothoracic glands for the first time. Variations in the name, such as prothoracic glands, thoracic glands, ventral head glands, tentorial glands have been used according to their location (in the thorax or head).

The evidence obtained from WILLIAMS's studies (in *Platysamia cecropia* [46, 49] clearly showed that a brain factor released by the neurosecretory cells of the pars intercerebralis induces the thoracic glands to secrete their substances "moulting and metamorphosis hormone, ecdysone". Since then various structures, the morphology of some of which has been known for a long time have been accepted to be homologous with the thoracic glands of *Lepidoptera*.

There are many papers about this subject, especially on the larval, nymphal and adult stages of insects but only a few on

the embryo [18, 19, 20]. Because of attention was directed towards the embryonic phase, JONES's experiments with the embryos of *Locusta pardalina and Lousta migratoria* are interesting and valuable.

According to ELLIS and CARLISLE [3, 4] the prothoracic gland of nymphs in isolated *S. gregaria* is larger than in crowded *S. gregaria* and is connected with colour change in the locust.

The main aim of this study is to see whether there is a difference in the ventral head glands of the embryos of the gregarious and solitary phases of *S. gregaria*.

MATERIAL AND METHODS

This paper is based on a study of the ventral head glands in the head of the embryos of gregarious and solitary phases of *S. gregaria* in order to compare the ventral head glands of both phases of embryos.

Some egg-pods of the gregarious phase of the insect laid on known dates were supplied by the Anti-Locust Research Centre, and sometimes adults, which were taken and permitted to oviposit in our laboratory. The egg-pods were collected daily. Thus, a series of eggs was obtained whose ages were known to within 24 hours.

The pods, in cups that contained sterilized sand, were kept at 32 °C. in an incubator from the first day until they hatched. At 24 hour intervals, the eggs were dissected from the egg-pods. The sand grains were brushed off gently, the eggs washed in water, dried with filter paper and fixed, the younger eggs with hot alcoholic Bouin's fluid and the older eggs with Carnoy lebrun [33, 21].

A variety of fixatives was tried for the eggs. Of these, alcoholic Bouin for the early stages, and Carnoy acetic alcohol (formula No. 2 Carnoy lebrun) for the late stages, gave the best results [33]. In order to secure proper fixation it was necessary to puncture the eggs in several places (on the side which does

not contain the embryo) with a fine needle after placing them in the fixative.

Locust eggs, even from the same pod, tend to develop at different rates. For this reason, the outer brown coloured chorion of the eggs was removed in a dilute solution of sodium hypochlorite to expose the transparent serosal cuticle. After this, it was possible to observe the growing embryo in RINGER's solution and to determine its position and state of development.

The eggs which were fixed in Carnoy lebrun were treated as follows: they were washed in iodized alcohol, cut in half and the halves that contained the embryos were stored in 70 % alcohol until needed. The eggs which were fixed in alcoholic Bouin's fluid were treated in the same way but without washing in iodized alcohol [37].

The difficulty of sectioning the yolky locust eggs was accentuated by the presence of a thick and almost impermeable vitelline membrane [33]. Because of these difficulties, SLIFER's and KING's methods [37] were applied. The eggs or embryos which had been kept in 70 % alcohol were exposed for 24 hours to 4 percent phenol in 80 % alcohol, dehydrated in 95 % alcohol and cleared in different agents, such as aniline oil, amyl acetate [7], methyl benzoate + 1 % celloidin (PETERFI's celloidin - Paraffin method) and were washed in chloroform, toluene or benzene respectively. They were then infiltrated with paraffin wax (52 °C., 56 °C.) in the usual way and blocked out. The paraffin wax trimmed away from the face of the block until the yolk was just exposed and then the block was soaked in water for 24 to 48 hours.

The essential features of this process consisted of the treatment with phenol ad soaking in water [37]. These two combined steps gave a perfect ribbon. The clearing agents methyl benzoate and methyl benzoate + 1 % celloidin were used most often and gave the best results.

The serial sections were cut from 5 to 8 μ thick. Different stains were used. These were MAYER's haemalum, HEIDENHAIN's azan [28]. GOMORI's chrome haematoxylin Phloxin [6, 14, 16]. Aldehyde-fuchsin (The GOMORI's technique [15]

was modified by HALMI [16] and DAWSON [6] and simpli-
fied by CAMERON and STEELE [2]). In this paper CHP stands
for GOMORI's chrome haematoxylin and AF for Aldehyde-
fuchsin and MH for MAYER's haemalum and HA for HEI-
DENHAIN's azan.

In the embryo the first three types of stain gave approxi-
mately the same results for the ventral head gland.

The results obtained with HA and CHP were better but
the method for MH was easier.

The very early hatchlings (less than 24 hours old) of both
phases of S. gregaria were also fixed in Bouin's fluid or Carnoy
lebrun. PETERFI's celloidin-paraffin method was applied [28]
and the above stains used. A micrometer eye piece was used
for measurement of the nuclear diameter. Photomicrographs
of selected slides were taken, using a Reichert microscope.

OBSERVATIONS

The dated egg-pods of both phases were kept in tiny deep
slender cups containing damp sand, in an incubator at 32 °C.

The embriyonic development of gregarious phase of S. gre-
garia usually lasted about 12 days, on the 13 th day the first
hatchlings appeared. Most of them were black in colour, no green
one having been seen, but a few green hatchlings less than
24 hours old were supplied by the Anti-Locust Research Centre.

The embriyonic phase of solitary locusts lasted about 14
days and on the 15 th day the locusts hatched. Many of them
were green in colour and only a few became black in the 24 hours.

It is well known that the rate of development of locust
eggs is variable; even eggs from the same pod tend to develop
at different rates. For this reason the stage of development of
the embryo was observed directly after removing the chorion.

After treatment as explained above, serial sections were
cut from 1 st day eggs and from every age taken at 24 hours in-
tervals afterwards until hatching age and from the very young
hatchlings (less than 24 hours old).

Serial sections prepared from each different age of the em-
bryos and from the first hatchlings, were stained with four dif-

ferent stains (MH, HA stain CHP, AF). The first three stains
gave good results, but none of them were outstanding.

The ventral head glands in the embryo in eggs laid by the
gregarious parents appeared for the first time on the 5,5 th day,
just after revolution (Katatrepsis). At this stage, the embryo
filled about half of the egg. The formation of the eye-pigments
had not yet begun. The embryo was connected with the yolky
material by the back of its head.

The ventral head glands arose in paired form from the epi-
dermis just anterior to and on either side of the second maxil-
lary segment (Fig. 1. A). It was located in a dorso-lateral posi-
tion posterior to the dorsally situated system of primary head
muscles and extended backwards and downwards to approach
the body wall joining with the sub-oesophageal ganglion and the
muscles and epidermis in the same region. At this early stage,
the glands tapered towards each end and were therefore largest
at the middle. Each was surounded by a thin connective tissue,
which did not appear to penetrate the substance of the gland.
The cytoplasm seemed syncytial and contained deeply staining
nuclei, all of approximately the same size. Sometimes, it was
possible to see the boundary of the cells. The nuclei were stai-
ned blue, darker blue and red, according to the stain used (MH,
CHP and HA respectively). However, according to the kind of
fixative, these colours become a little lighter or darker. In some
parts of the cytoplasm granules of various sizes were detected
(Fig. I B).

These could be seen with various stains e. g. blue violet with
MH, blue or deep blue with CHP and violet-yellowish and red-
dish with HA. Sometimes, it was possible to see some branches
of nerves and tracheoles extending to the ventral head glands,
but once inside it they could not be traced. Sometimes, in some
nuclei it was possible to distinguish a nucleolus. At this stage
the diameter of circular nuclei was measured in 10 different
specimens and the figures from at least 100 nuclei were avera-
ged. The mean, max. and min. diameters of the nuclei at 24 hour
age intervals are shown in table I.

On the 6 th **day:** The embryo filled 4/5 of the egg and sho-
wed the beginning of the formation of eye pigment. At this stage,
the nuclei of the ventral head gland became a little larger.
The cytoplasm showed a little vacuolation. Mitosis was seldom
seen in the nuclei.

On the 7 th **day:** The embryo filled the egg. The pigmenta-
tion of the eye was developed. But the formation of melanin in the
body had not begun yet. At this stage, the gland contained
deeply staining nuclei of various shapes and sizes. The nuclei be-
came much larger and some of them lobulated and the cytop-
lasm looked like a network, with vacuoles and granules.

These granules stained dark and light violet-bluish with
CHP (these colours changed a little according to the fixative
used) and reddish, yellowish and light violet with HA. These
organs now tapered much more noticeably at both ends and
were more curved towards the inside than before. In fact, they
reached the sub-oesophageal ganglion. They also began to show
some branching.

On the 8 th **day:** At this stage the pigmentation of the eye
increased, but the formation of body melanin had not yet be-
gun. The nuclei of the ventral head gland became much smal-
ler and the size difference was much clearer. Some nuclei seemed
to have broken down and chromatin droplets could seldom be
seen in the cytoplasm. In some places, the cytoplasm appeared
vacuolar and contained granules.

On the 9 th **day:** The formation of melanin began in the head
region. but it was a very pale brown in colour. The nuclei of
the ventral head glands became much larger with regard to 8
day embryos. Chromatin droplets were also seen. Although mi-
tosis was not often observed, it had been seen mostly at this
stage. (Fig. I C).

On the 10 th **day:** The teeth of the mandibles and the head
region were a pale brown colour. At this stage the nuclei of the
ventral head glands were much more lobulated than before, and
they reached their maximum size. The cytoplasm was much
vacuolated, in some places looking like a network, and it also

contained many granules. Small tracheoles were also distinguish-
able inside the cytoplasm. (Fig. I D).

On the 11 th day: The mandibular teeth of the embryo were
brown in colour and the head region was light brown. The nu:-
lei of the ventral head glands became smaller and showed some
break down. Mitosis was seldom seen.

On the 12 th day: The embryo was ready to hatch. The man-
dibular teeth, leg spines and head capsule were brown in colour,
but there was no pigmentation on the thorax or the abdomen.
At this stage the nuclei became smaller and the glands, espe-
cially near the tentorium, had the appearence of a rope of one
or two rows of cell.

After 12 th day: On the 13 th day at 32°C., many eggs of
the egg-pod hatched. 24 hours after hatching (melanin pigmen-
tation had appered on the whole body), the structure of the vent-
ral head glands was examined. They were at the back of the head.
Anteriorly, the pair of ventral head glands (at both sides)
were connected to the dorso-lateral epidermis and muscles, then
curved inwards and crossed downwards to join the sub-oesopha
geal ganglion, epidermis and muscles (Fig. I E).

In the hatchlings of the gregarious phase of *S. gregaria*,
green pigmentation has not been met in our material, but a few
very early green hatchlings were given by the Anti-Locust Re-
serach Centre.

In the black and green locusts, the mean, max. and min.
diameters of the nuclei were measured and the figures were also
given at the table I.

The same experiments were made on the embryo of the
solitary parents phase of *S. gregaria*. The speed of embryologi-
cal development was slower than that of the gregarious phase. They
hatched on the 14 th or 15 th day. Most of them had green, but
some of them had black pigmentation.

On the 5,5 th day: None of the embryos had completed re-
volution although some were just beginning of it.

On the 6 th day: Some of the embryos had just completed revolution and some of them were just before revolution. The embryos that had completed revolution were chosen and treated for this stage.

The ventral head glands were first met at this stage of the embryos. The structure and location of the ventral head glands in the solitary phase of *S. gregaria* were like those of the gregarious phase embryos. At 24 hour age intervals the diameters of the nuclei were measured and the mean diameter was calculated. After 7 days the shape and size of the nuclei were altering. For this reason circular nuclei were chosen for measurement. All measurements were taken from 7–10 specimens from every stage and from at least 100 nuclei, the averages being as follows (at the table I).

TABLE: 1.

Diameter of the nuclei in the embryos of the both phases of
S. gregaria (FORSK.)

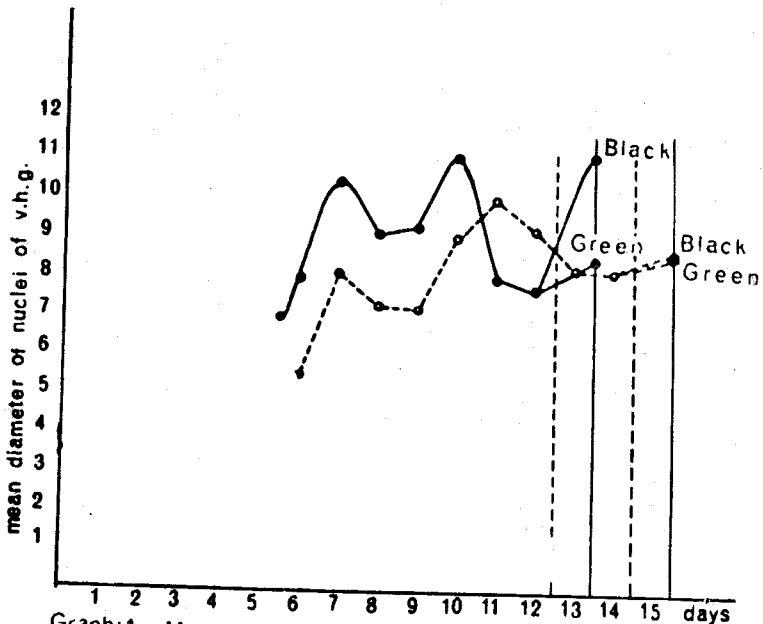| Gregarious phase				Solitary phase			
Age of embryos (days)	Mean diameter μ	Max. μ	Min. μ	Age of embryos (days)	Mean diameter μ	Max. μ	Min. μ
5 5	6.88	8.75	3.75	6	5.39	7.50	3.75
6	7.88	10	6.25	7	7.98	12.50	3.75
7	10.29	15	6.20	8	7.14	11.25	5
8	8.97	15	5	9	7.08	12.50	3.75
9	9.10	15.60	5	10	8.85	13.75	5
10	10.90	20	5	11	9.82	20	5
11	7.84	13.75	5	12	9.06	15	5
12	7.58	12.50	5	13	8.01	15	3.75
24 hours after hatching				14	8.02	15	3.75
Green	8.32	12.50	5	24 hours after hatching			
Black	10.91	17.50	5	Green	8.41	13.75	3.75
				Black	8.50	12.50	5

Variations in the size of the nuclei of both phases were shown in the graphs as follows:

If graph I is examined, two cyclic activations of the ventral head glands can be seen easily for both phases. The activation of the ventral head glands can be judged by the increase

in size of the nuclei, their lobulated shape and much more deeply staining cytoplasm [45, 19, 20, 39].

In the embryos of gregarious and solitary phases of S. gregaria, the first peak in size of the ventral head glands, coincided with the 7 th day embryos. On this day, the epidermis was retracted from the cuticle. JONES has suggested that in locust embryos these glands are exclusively concerned with the retraction of the epidermis from the cuticle [19].
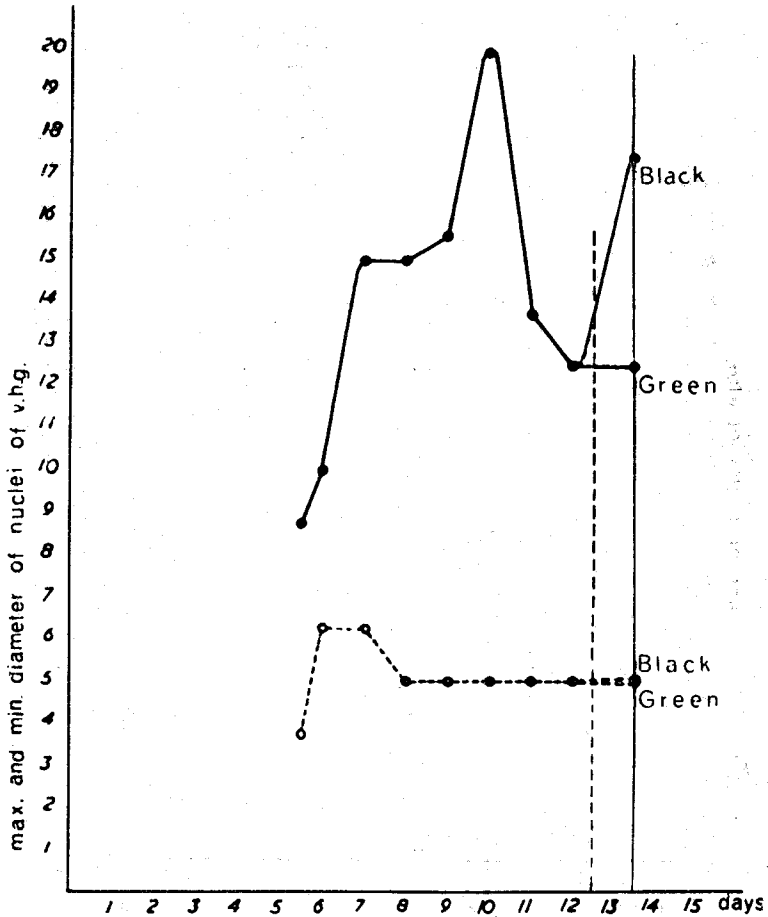
The second peak in the embryos of the gregarious phase of S. gregaria was coincident with the 10 th day. The formation of melanin first began as a very pale brown in colour in the head region of the gregarious phase embryos on the 9 th day. On the 10 th day this colour became much darker in the head region.

Graph:1 - Mean diameter of nuclei of v h.g. of embryos
and first hatchlings of both phases of S
gregaria (Forsk).
———— gregarious phase
----- solitary phase

I have never seen the spreading of melanin pigmentation over the abdomen of the embryo as in *Locusta migrotaria* and *pardalina*. In the gregarious phase this pale pigmentation over the head appeared to be connected with the activation of the ventral head glands. This also agreed with JONES's paper [20], (The amount of melanin deposited appears to be correlatad

Graph 2 - Max and min diameter of nuclei of v.h.g. of embryos and first hatchlings of S. gregaria gregarious

with the amount of development hormone released from the ventral head glands).

This second peak size in the embryo of the solitary phase of S. *gregaria* occurred in the 11 th day embryos. (because of their much slower development process). After the second peak the nuclei of the ventral head glands became smaller before hatching.
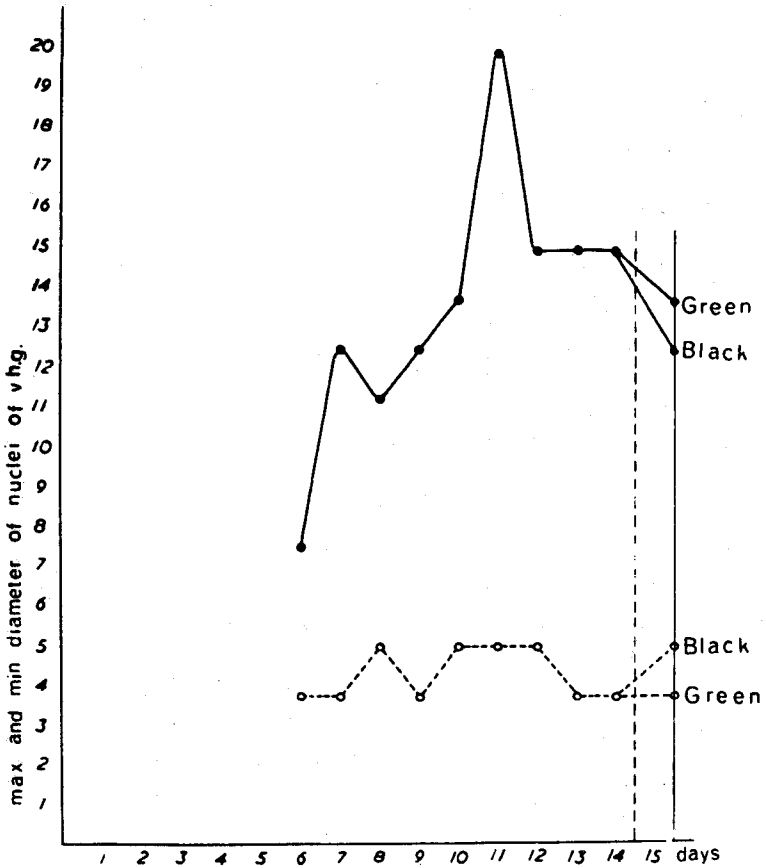
Graph 3 · Max and min. diameter of nuclei of v·h·g. of embryos and first hatchlings of S. gregaria solitary

The activation of the ventral head glands seemed to be cyclic in both phases, but according to the measurements of the nuclei of the ventral head glands in the embryos of the gregarious phase of S. gregaria were larger than those of the embryos of the solitary phase. It is clear that a gland which contains nuclei of great diameter has a large volume because of the number of nuclei and in both phases of the same species this should be constant. [WELLS [45] showed that the number of nuclei in each thoracic gland is surprisingly constant, being about 300 in almost all the species examined in the same family, (Hemiptera-Heteroptera) the volume of the gland being greater in the larger insects by increase in the size of the individual nuclei].

In the 24 hour black hatchlings, the mean diameter of the nuclei was larger than that of the green hatchlings of the same age. But in the solitary phase this difference was not very marked according to colour. The mean diameter of the nuclei of the black appeared to be a little larger than that of the green, but from some of the green hatchlings measured, the nuclei were much larger than those of black specimens. This suggested that there was no direct relation between the ventral head glands and the green colour. STAAL [38] also suggested the same conclusion about locusts.

DISCUSSION

Recent studies have demonstrated that the glands which are known as ventral glands or tentorial glands, pericardial glands, and prothoracic glands have an important role in the growth and moulting processes of metamorphosis in insects.

The possibility of a homology between these organs which have been described by different authors, has only been shown in a small number of insects such as Thysanurans [12], Carausius morosus, the larva of F. auricularia [29, 30, 31], Forficula [25], Locusta migratoria, [39, 40], L. migratoria [17], L. migratoria embryo [19, 20].

The thoracic glands (Hemiptera - Heteroptera) originate embryonically from the walls of the second maxillary segment as invaginations [45]. In many insects, the prothoracic glands

develop into two parts, one forming the ventral head glands
with a final position in the head [*Thysanurans* [12], *Forficula
auricularia* [25], *Carausius morosus* [28], *L. migratoria* [38].
L. pardalina and *L. migratoria* embryos [19, 20]) and the other
the prothoracic glands proper with a final position in the pro-
thorax (*Leucophae-cockroach* [35, 36], *Lepidoptera* [24], *Platy-
samia cecropia* [46, 47, 48, 49], Silkworm [9, 10, 11], *Hemip-
tera-heteroptera* [45, 8], *coleoptera* [42, 43], *Gryllides* [34], *Pe-
riplanata americana* [1], Cockroach [5], *Iphita limbata-hemip-
tera* [27], *L. migratoria* [17], *Rhodnius* [50, 51].

It can be seen that the glands in the primitive groups tend
to be in the head region, while in the more advanced groups,
there is a tendency for them to be located more posteriorly.

The presence of a pair of ventral head glands in the locust
embryos homologus with the thoracic glands was first determined
in *L. pardalina* and *L. migratoria* by JONES [18, 19, 20]. He
was the first to trace these organs after revolution and these
embryos which had completed katatrepsis.

In also my experiments the ventral head glands were first
detected just after revolution, and the embryo had attained
only half the size of the egg. This pair of glandular organs ori-
ginated as invaginations from the epidermis just in front of the
second maxillary segment. But it is difficult to be certain of this
fact i. e. in front of the second maxillary segment since at this
stage in *Schistocerca* the mandibles and maxillae have already
become pushed into the head. PFLUGFELDER [29, 31] descri-
bes in *carasuis morasus* their development from epidermal pro-
liferations in the ventro-caudal part of the head, but that they
soon separate from the epidermis and become bladder-like.
JONES [19] suggests their origin as invaginations in the head
region only of embryos of *L. migratoria* and *L. pardalina.*

The ventral head glands in *S. gregaria* are located in the
posterior region of the head and are connected with the sub-
oesophageal ganglion, epidermis and muscles at the ventro-cau-
dal end and also joined to the muscles and epidermis at the dor-
so-anterior end. Their location in the embryos of *L. pardalina*
and *L. migratoria* is the same. In the embryos of *S. gregaria*, these

organs appear to taper at each end before joinning the epidermis and muscles. This fact is also the same in the embryos of *L. migratoria*, but in *L. pardalina* there does not seem to be any tapering at each end [19, 20]. The structure of the ventral head glands in *S. gregaria* was similar in the embryos of *L. migratoria* and *L. pardalina*. The cytoplasm was syncytial, and contained deeply staining nuclei of various shapes and sizes, according to the embryological stage. The activation of the ventral head glands can be understood by reference to the cyclic changes in the nuclei of the glands [45]. At the active stage, the nuclei of the ventral head glands became much larger and more lobulated on the 7 th day and 10 th day in the embryos of the gregarious phase of *S. gregaria* at 32°C.

The ventral head glands were surrounded by a thin connective tissue membrane, but this was untraceable inside the ventral head glands as in gryllides and *L. migratoria* [39]. On the contrary, in *Leucophae* [35], and *Bacillus rosü-Phasmidae* this membrane penetrates inside the ventral head glands.

In *Leucophae* its longitudinal axis is occupied by a trachea, several parallel fibres of striated muscle and a nerve derived from the prothoracic ganglion [35].

The ventral head glands in the embryo of *S. gregaria* may be situated very close to trachea. However some small tracheoles can be recognized in some sections of the older embryos. In *Rhodnius* [50, 51] in *Hemiptera - Heteroptera* [45], and in *Gryllides*, [34], the glands are well supplied by tracheoles. Connection of small nerves to the ventral head glands can be seen in the embryos of *S. gregaria*, but no nervous tissue can be detected inside it as in, *L. migratoria* [39], the embryos of *L. pardalina* and *L. migratoria* [19, 20], *Hemiptera* [45], Gryllidae [34], *Coleoptera* [42], and *Rodnius* [50, 51]. On the contrary, in *thysanurans* [11], *Lepidopterous*, [24, 47], cockroaches [35], and *Stenobothrus rufipes* [31], the glands are innervated.

Although the ventral head glands are distinctly paired in origin in most insects an exception is in the *gryllidae*, when they are completely fused to form one organ, as described by SEL-

LIER [34]. Though mitosis seemed seldom to occur, it was mostly
seen in the 9 th day embryos of *S. gregaria*. SELLIER [34]
also described mitosis as occurring very infrequently in the last
larval stages of Gryllides. But STRICH [39] desribed it at
every nymphal stage of *L. migratoria* and determined the func-
tion of the ventral head gland according to the number of cells
undergoing mitosis.

The ventral head glands of *S. gregaria* are ductless as in
other insects.

The results of studying the ventral head glands in the em-
bryos of *S. gregaria* (both gregarious and solitary phases) sho-
wed that there were two cyclic activation periods (graph 1). The
first maximal activity was concerned with the retraction of the
epidermis from the cuticle. The experiments of JONES [19],
on the embryos of *L. pardalina* and in *L. migratoria* gave the
same results. He also showed some relationships between the
beginning of deposition of melanin and the ventral head glands
by his ligaturing experiments [20]. The deposition of melanin
in *Locusta* embryos began at the end of the abdomen and spread
towards the anterior of the embryo. In the gregarious phase of
S. gregaria embryos, deposition of melanin first took place, eye-
disc excepted, in the head region (anterior) of the embryo. At
this time on the 10 th day, the nuclei of the ventral head glands
reached their largest and most lobulated shape. This maximal
point coincided with the deposition of melanin on the 10 th day.
JONES also claimed that in Locust embryos the deposition of
melanin is initiated after the moult has taken place, and its
gradual spread continues up till time the embryo is ready to
emerge.

The ventral head glands, nuclei decreased in size after their
second maximal active period and began to increase in size again
after hatching.

CARLISLE and ELLIS [3, 4] suggested that the protho-
racic glands may also have an influence on the phase charac-
ters in locusts. In nymphs newly emerged adults the prothora-
cic glands of isolated reared insects are larger than those of

crowded insects. The extirpation of the greater part of one of the pair of prothoracic glands in the fourth instar solitary nymphs leads to the assumption of a gregarious habit and the gregarious pattern of pigmentation. Finally, they stated that there were positive quantitative relations between the green colour of *Schistocerca* and the prothoracic glands. (I preferred to use the name of ventral head gland because of its location). But at the same symposium (1961) CARLISLE accepted that the pigmentation, the biometric ratios and behaviour were presumably affected by two or more hormons released from two or more endocrine organs. STRICH HALBWACHS [39, 40] did not find any direct effect on the differentiation of the adult structure and pigmentation with the implantation and extirpation experiments in *L. migratoria*. I also did not find any really direct relation between green colour and the ventral head glands in the solitary phase, But in the gregarious phase embryos and hatchlings there appeared to be some relation between melanin pigments and the ventral head glands. The function of the ventral head glands has apparently not been found to influence the determination of phase dimorphism. The ventral head glands exert no appreciable influence upon the pigmentation of Locusta larvae [38]. ALBRECHT found the decreasing number of nymphal instars to be connected with the gregarious status of the hatchlings [38]. And STAAL [38] states that in his experiments the development within fewer instars was a result of increased the ventral head gland activity. He compares this result with the greater volume of the ventral head gland in solitary nymphs of *Locusta* and *Schistocerca* observed by ELLIS and CARLISLE and presents an unexplained contradiction when it is indeed true that a greater volume of the ventral head gland means more secretion.

In my study of the solitary phase embryos of *S. gregaria*, the ventral head glands are much smaller than those of the gregarious phase. The embryos of the solitary phase and also the hatchlings were smaller than those of the gregarious phase. KENNEDY [22] also found with *Nomadacris* and *Schistocerca* that isolated parents produced offspring that were smaller at hatching than the offspring of crowded parents, grew more slowly, and more often underwent an additional moult as nymphs. My

result aggrees with STAAL's [38], and WELLS's paper [45]. According to WELLS's description of the thoracic glands of *Hemiptera-Heteroptera*, the volume of the gland is made greater in the larger insects by an increase in the size of individual nuclei. The mean diameter of the nuclei of the ventral head glands of all the very youngest black hatchlings of both phases, is larger than that of the green hatchlings. But the difference is not very evident, especially in the solitary phase. Sometimes the max. diameter of the nuclei was found to be larger in the ventral head glands of individual solitary green specimens.

It is clear that there is no direct relation between the ventral head glands and green pigmentation. It is necessary to continue experiments and much more time is needed to get exact results. It might be true that the pigmentation, biometric ratios and bahaviour are all affected by two or more hormones secreted by two or more endocrine organs.

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ÖZET

Schistocerca gregaria (Forsk.) un greger ve soliter faz embriyolarında ventral baş bezlerinin yapısı tetkik edildi. Bu bezler embriyonun yumurtanın posterior kutbu etrafında dönüşünden hemen sonra epidermisten, ikinci maksiller segmentin her iki tarafından meydana gelir, ilkel baş kaslarının dorzalinden başlıyarak içeriye ve geriye doğru uzanarak sub-oesophagus gangliyonu ile birleşirler.

Bez sinsityal bir yapıdadır, koyu boyanan loplu nükleüsleri vardır. Sitoplazma-da vakuoller görülür.

Her iki fazın embriyonik devreleri boyunca bezin yapısında peryodik iki aktif devre görülür. Birinci maksimum aktif devre embriyonik kutikulanın epidermisten ayrılmasile, ikincisi de melanin pigmentinin teşekkülü ile ayni zamana rastlar.

Soliter faz embriyolarının ventral baş bezleri gregerlerden daha küçüktür. Bu küçüklük faz karakterinden ziyade esasen daha küçük olan embriyo boyları ile ilgili görülür.
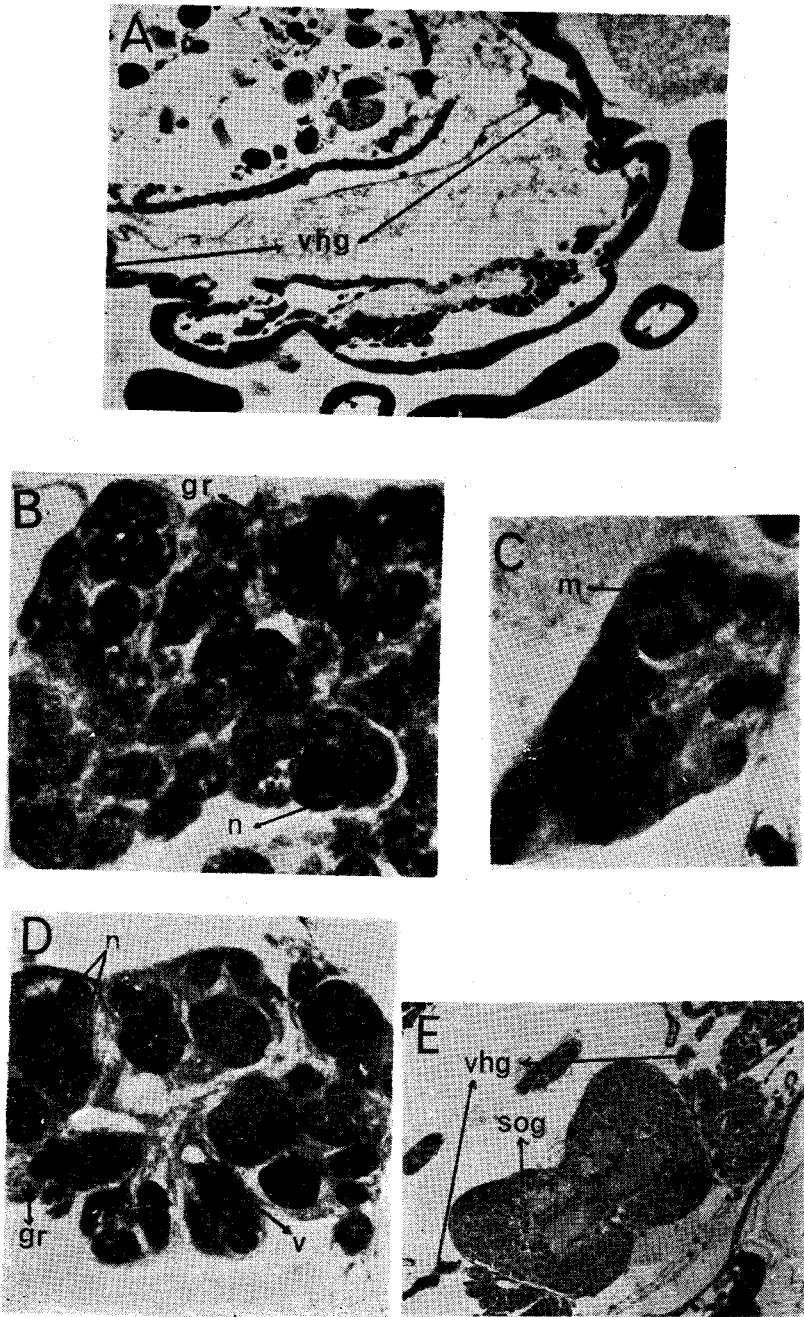
Fig. 1

Fig. 1: Photomicrographs of sections of ventral head gland of embryos in *S. gregaria* (gregarious phase).

A–On the 5, 5 th day. Fixed with alcoholic Bouin, stained MH. 8 x 10 x 3 =x 240.

B–On the 5, 5 th day. The same treatment. 12, 5 x 63 x 3 = , x 2362.5

C–On the 8 th day. Mitose (telophase). Fixed carnoy lebrun, stained with MH. 12, 5 x 40 x 3 = x 1500

D–On the 10 th day. Fixed carnoy lebrun, stained with CHP 12, 5 x 40 x 3 = x 1500.

E–Connection of ventral head gland with sub-oesophageal ganglion fixed carnoy lebrun, stained with MH. 8 x 10 x 3 = 240

vhg–Ventral head gland, gr. granule, m-mitosis n–nucleus. sog-suboesophageal ganglion v–vacuole.