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Heliothis Dispersal and Migration

Compiled by M.W. WIDMER and P. SCHOFIELD

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PREFACE

A few of the many species of Heliothis (Lepidoptera, Noctuidae) are important crop pests in the Old and New Worlds. Among these, H.armigera, H.zea, H.virescens and H.punctigera are the best known. The former is a particularly destructive species of a wide range of crops cultivated in Africa, the Middle East and Asia, including several staple foods and important peasant farmer cash crops. As new cultivation techniques are introduced and more extensive areas of crops are grown, often on larger irrigation and Government development schemes, it appears that this pest is becoming increasingly important.

There is a strong suspicion that H.armigera populations move locally between crops grown in sequence or intercropped and that probably more extensive migratory movement occurs, as has been demonstrated in the closely related species H.zea in North America. This has considerable implications for effective control of the pest on the crops of some of the least privileged farmers of the Developing World and in some of the poorest countries.

There are recorded instances of resistance to pesticides in the species. Clearly large scale movements could have an effect on dissemination of such resistance and affect the level of control exerted by local parasite and predator populations and hence the necessity for rapid control action to combat rapid population increases of the pest on both staple food and cash crops. The ability to forecast or warn of such incidents would assist in effective timing of control operations and maximise efficiency of any insecticidal input required.

This bibliography consolidates much of the scattered literature on the migratory behaviour of Heliothis spp. and will help to identify gaps in the existing knowledge of this aspect of the ecology of the genus. It will hopefully assist in focussing attention on the necessity for work on H.armigera, which is of such great importance in Developing Countries. Work on migratory movement could lead to effective action both regionally and internationally to reduce possibilities of migration of damaging numbers of moths. It will certainly assist in increasing knowledge on the bionomics of one of the most damaging agricultural pest species in the Old World and be of benefit to some of the least advantaged farmers of the tropics.

J.C. Davies, O.B.E., Ph.D., M.I. Biol.

Assistant Director

Tropical Development and Research Institute

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INTRODUCTION

1. Scope of the Bibliography

This Bibliography contains citations concerning the migration and dispersal of Heliothis spp. throughout the world, arranged in two sections, OLD WORLD and NEW WORLD. The OLD WORLD section includes unusual observations of the genus outside of its expected range together with other trapping records and any evidence of large-scale dispersal or migration. The NEW WORLD section concentrates on strictly migratory evidence. Hopefully, omissions have been kept to a minimum although some are inevitable. The compilers would welcome notification of any serious omissions which may at a later date be incorporated into a supplement.

2. Species names

The names of the Heliothis species given in the annotations (see 3.) are those in current use by the Commonwealth Institute of Entomology, London, UK. If an earlier synonym is used by an author in the title, this is given in the annotation in brackets after the currently accepted name. Both Chloridea and Helicoverpa are synonyms of Heliothis. The specific name obsoleta was assigned to both Old and New World species before they were recognised as distinct, and are currently named armigera and zea respectively; dipsacea, referred to in several papers, is a synonym of viriplaca.

3. Arrangement of citations

The bibliography is divided into two sections; Old World, including Australia, New Zealand and the Pacific but excluding Hawaii, and New World covering the Americas and Hawaii. New World citations refer to the cotton bollworm H. zea (Boddie), the tobacco budworm H. virescens (Fabricius) and H. subflexa (Guenée); Old World citations refer to:

<u>H. armigera</u> (Hübner)	<u>H. peltigera</u> (Denis & Schiffermüller)
<u>H. armigera armigera</u> (Hübner)	<u>H. punctigera</u> Wallengren
<u>H. armigera conferta</u> Walker	<u>H. rubescens</u> (Walker)
<u>H. assulta</u> Guenée	<u>H. scutuligera</u> Guenée
<u>H. assulta afra</u> (Hardwick)	<u>H. viriplaca</u> (Hufnagel)
<u>H. imperialis</u> Staudinger	<u>H. xanthiata</u> Walker
<u>H. incarnata</u> Frivaldsky	
<u>H. nubigera</u> Herrich-Schäffer	

Within these sections, the citations are arranged alphabetically according to author. If there is more than one reference to the same author(s), then they are arranged chronologically.

4. Distribution maps

Commonwealth Institute of Entomology Distribution Maps nos. 15, 262, 263, 283 and 239 for H. armigera, H. assulta, H. punctigera, H. virescens, and H. zea are reproduced over. Full supporting data is supplied with originals obtainable from CIE, 56, Queen's Gate, London SW7 5JR.

5. Information Sources

This bibliography is based on documents retrieved by searching, manually and/or by computer, the following:

The library stock of the Tropical Development and Research Institute (College House)

Abstracting periodicals published by the Commonwealth Agricultural Bureaux (UK), eg. Review of Applied Entomology, (Series A)

Those produced by BioSciences Information Service (BIOSIS) (USA) ie Biological Abstracts and Reports, Reviews and Meetings

AGRICOLA, the database produced by the Science and Education Administration, Technical Information Systems of the U.S. Department of Agriculture

The International Information System for the Agricultural Sciences and Technology (AGRIS), coordinated by the Food and Agricultural Organisation of the United Nations, Rome

The most recent issues of the most productive primary journals.

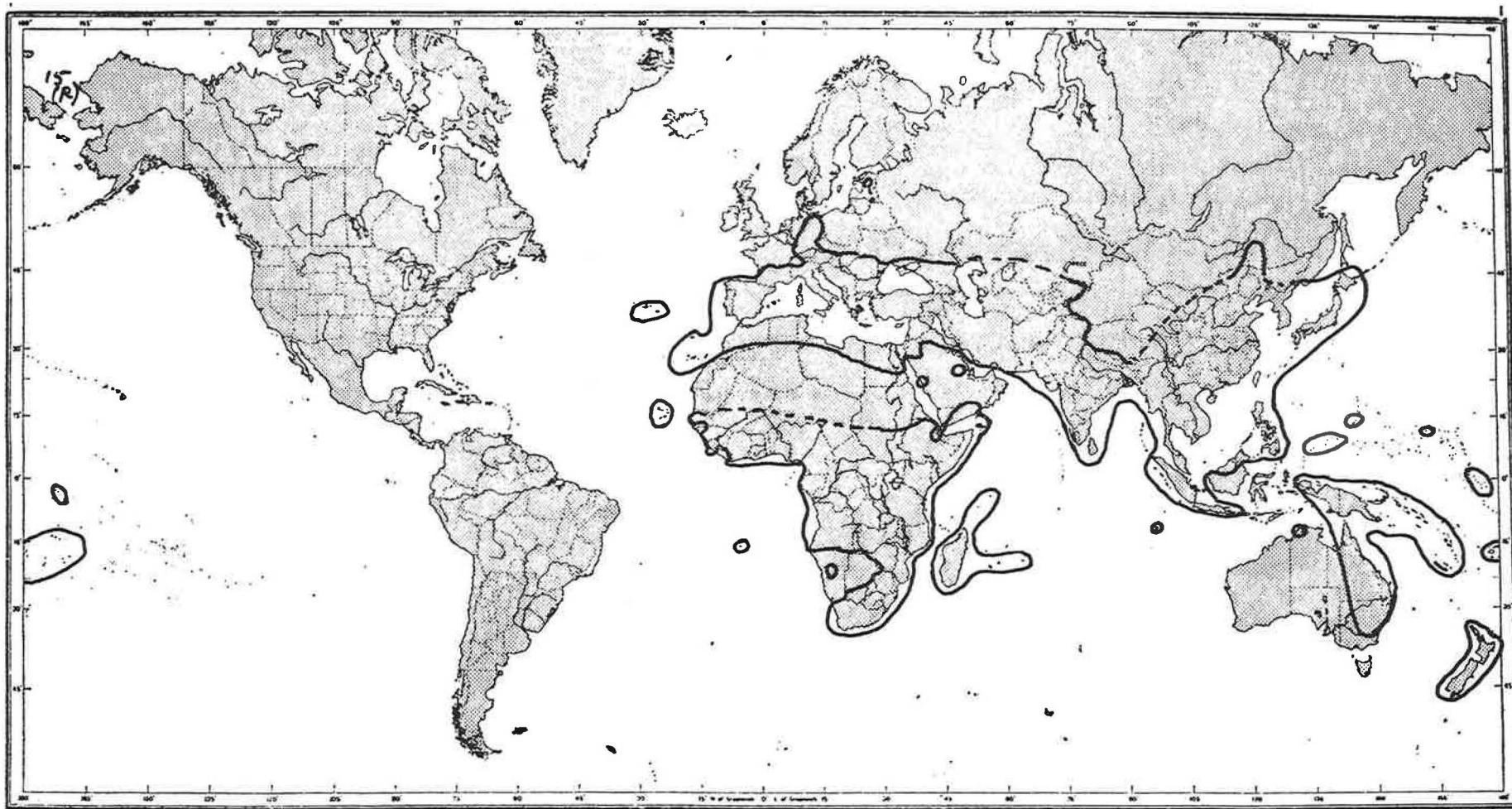
6. Language Symbols

Where the document is in a language other than English, the original title is given, followed by an English translation. At the end of the citation, the original language of the paper (using an initial capital letter) and the language(s) of any summary(ies) (using a small initial letter) are indicated in square brackets with the following symbols:

Af	Afrikaans	Ja	Japanese
Ch	Chinese	Ko	Korean
De	German	Nl	Dutch
En	English	Ru	Russian
Es	Spanish	Sv	Swedish
Fr	French		

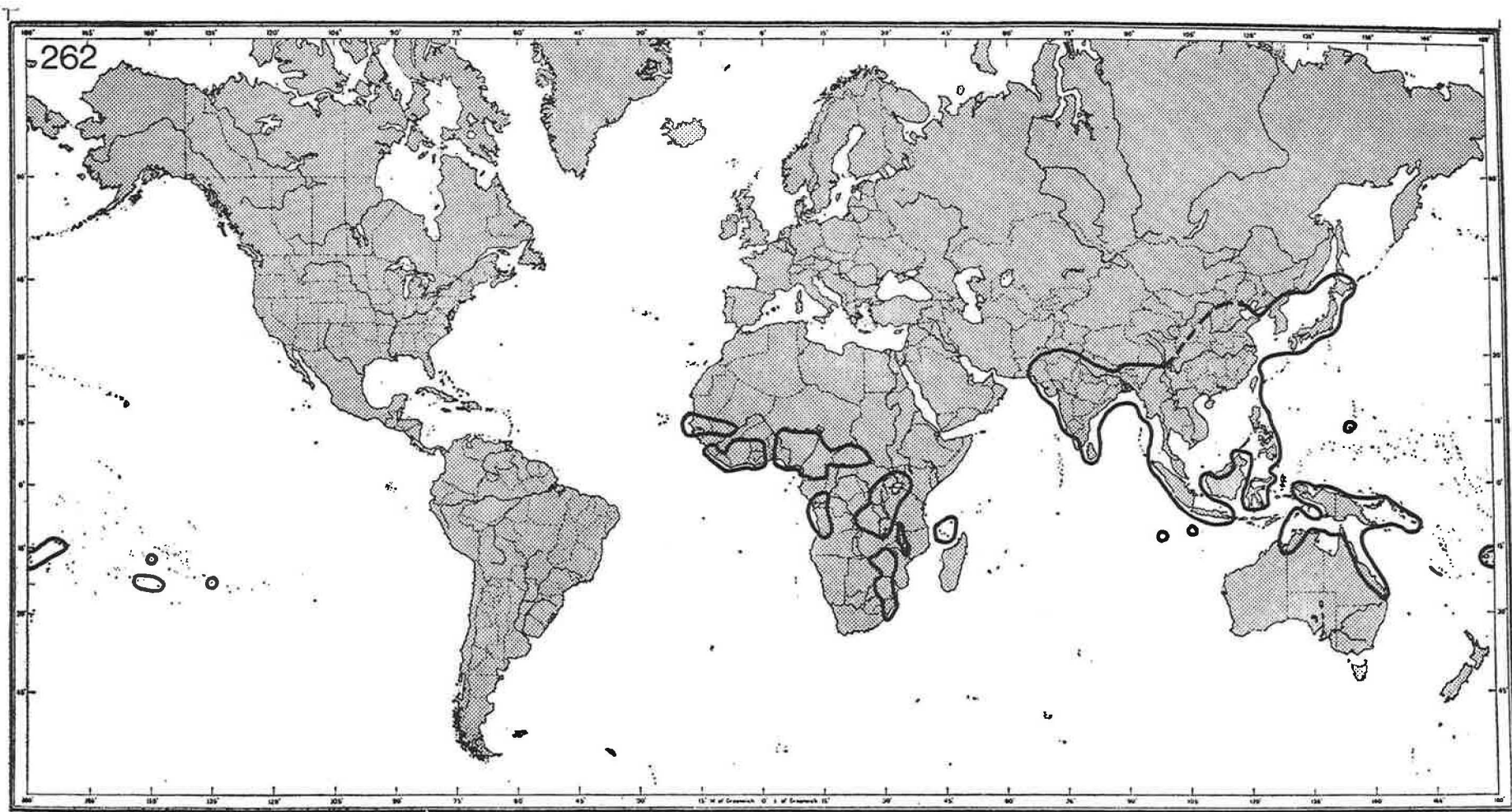
7. Indexes

Full author, species and country indexes are included.



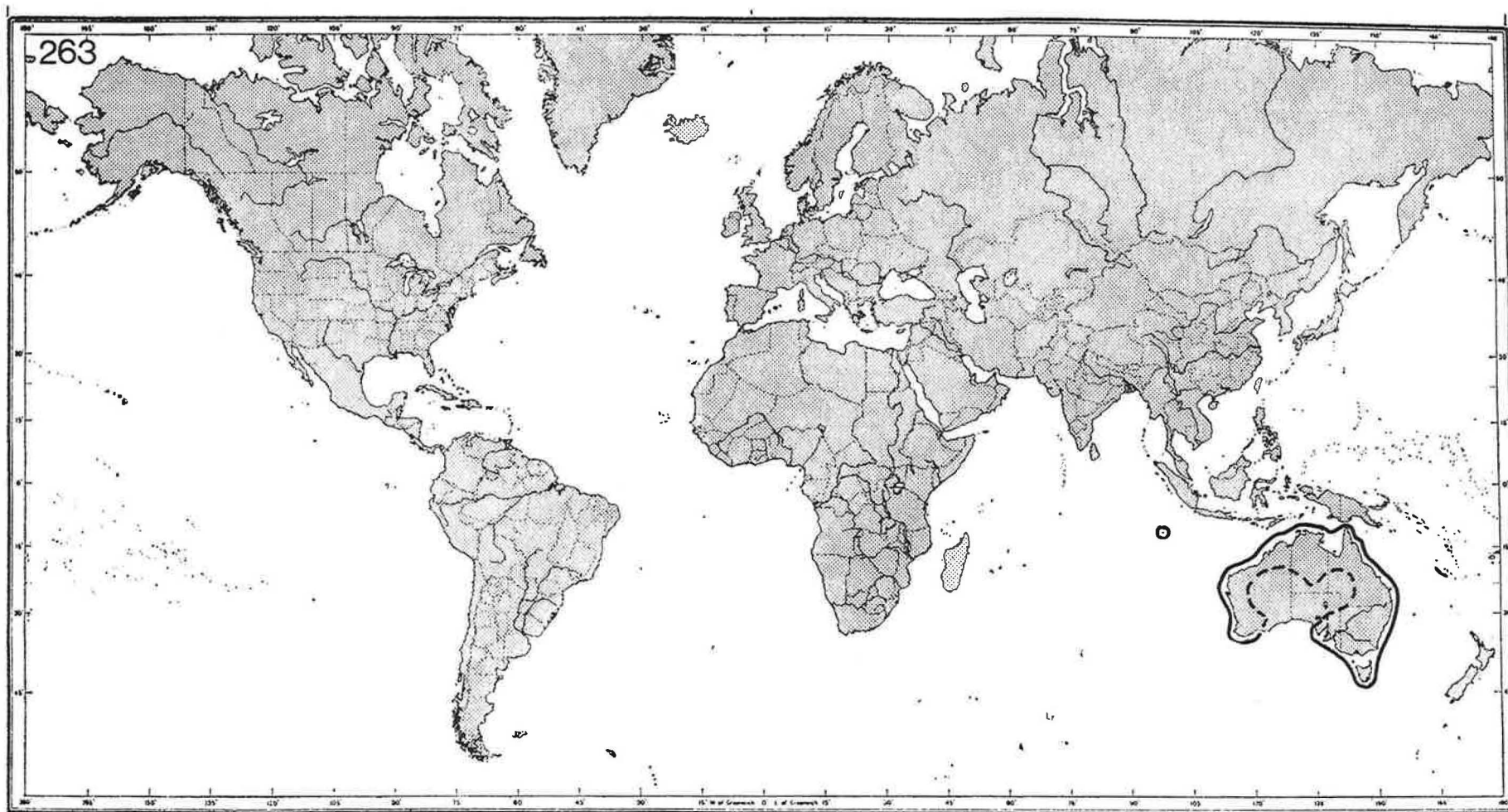
Heliothis armigera (Hübner)

C.I.E. Distribution Map No. 15 (1968)



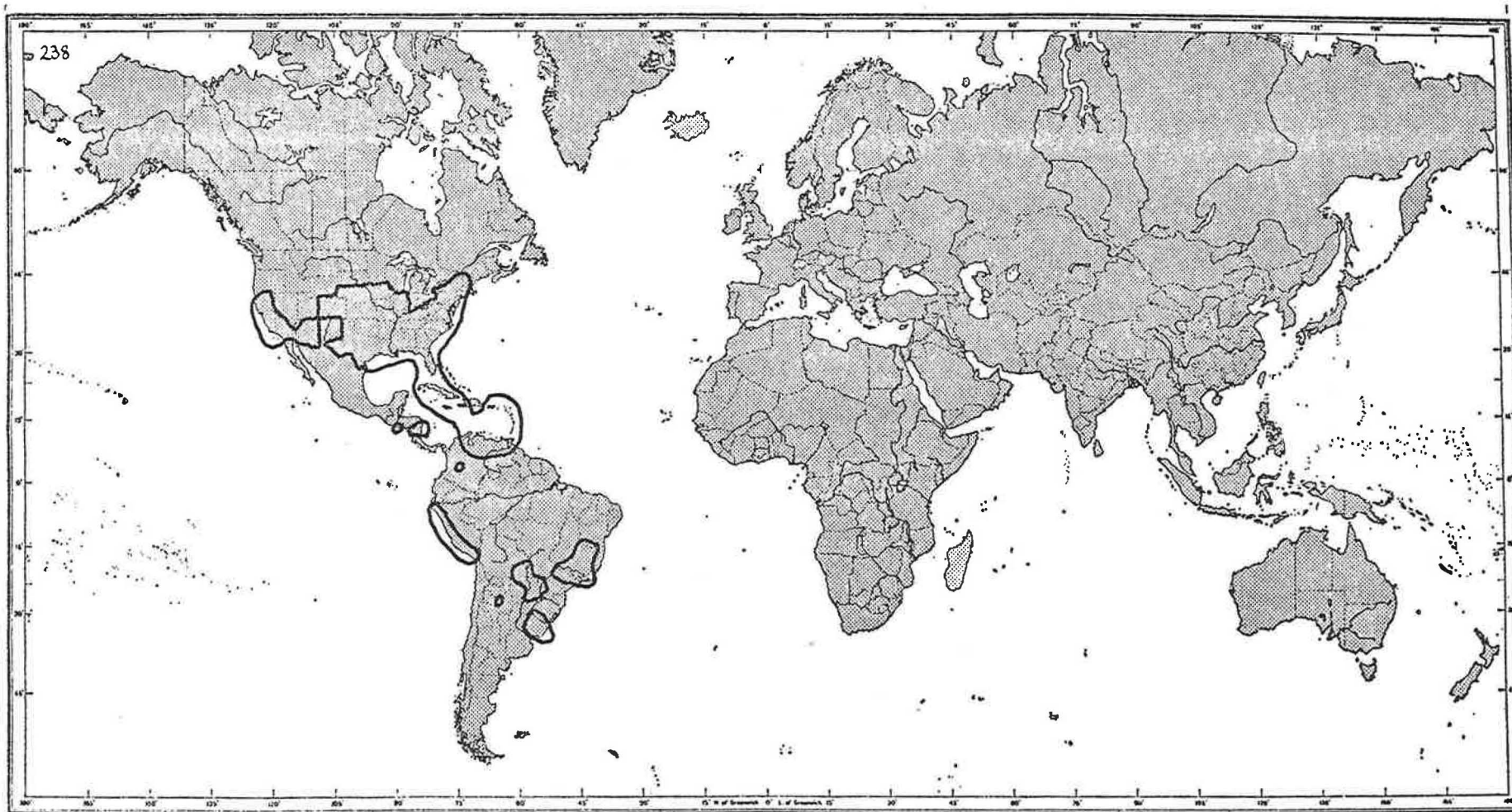
Heliothis assulta Guenée

C.I.E. Distribution Map No.262 (1969)



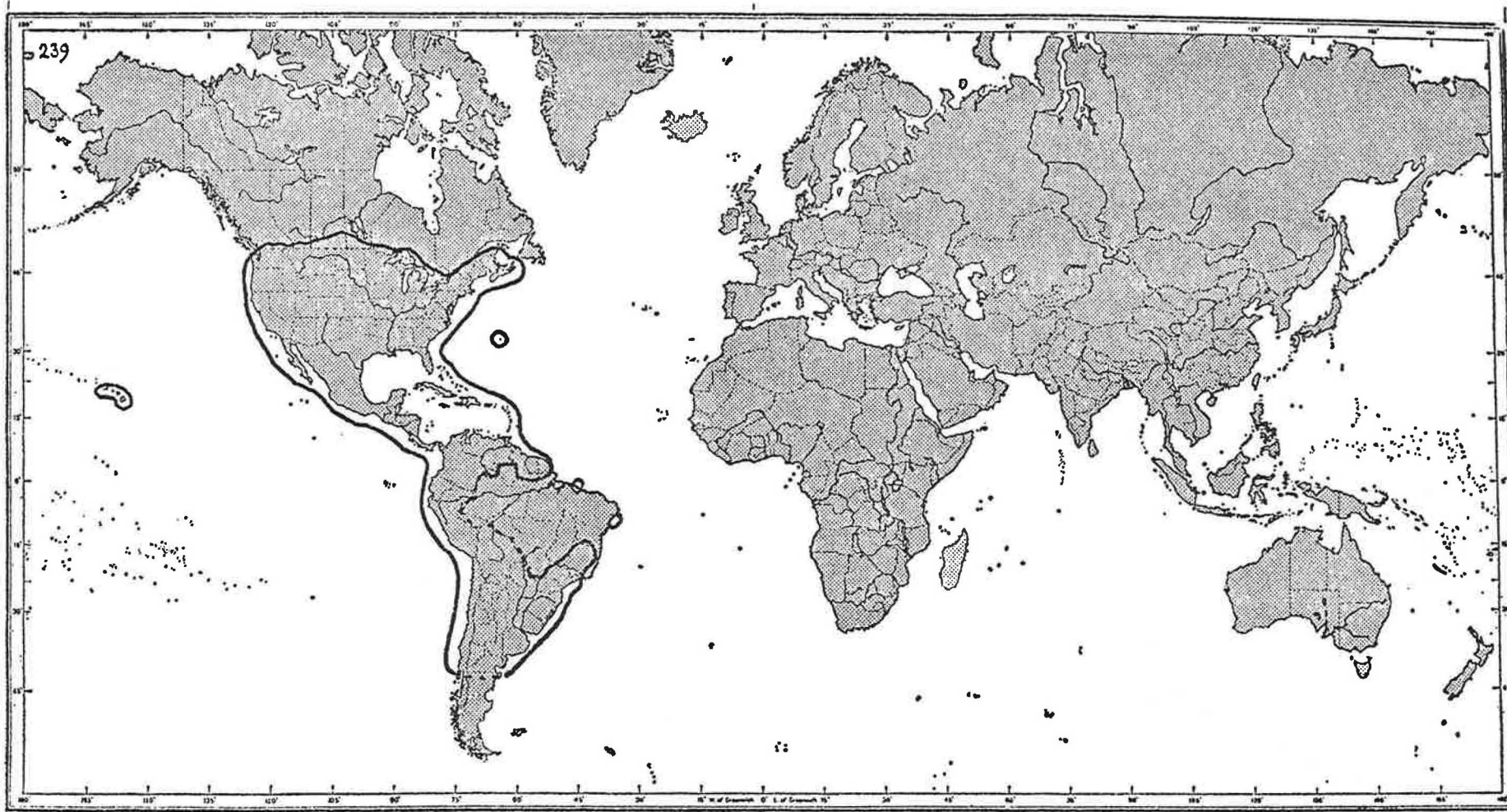
Heliothis punctigera Wallengren

C.I.E. Distribution Map No.263 (1969)



Heliothis virescens (Fabricius)

C.I.E. Distribution Map No.238 (1967)



Heliothis zea (Boddie)

C.I.E. Distribution Map No.239 (1967)

8. Obtaining original material cited in the Bibliography

- 8.i. **The Institute regrets that it is unable to supply any of the documents cited.**
- 8.ii. The literature should be available through the usual distribution channels including local library services and national library and documentation centres.
- 8.iii. When ordering material from any source, do not only quote the reference number in the Bibliography but include all the details of the citation ie. author(s), title, journal reference, date, etc.

BIBLIOGRAPHY

OLD WORLD
(Inc. Australia and New Zealand)

001 ADDIS ABABA INSTITUTE OF AGRICULTURAL RESEARCH. (1969). Report for the period March 1968 to March 1969. Addis Ababa, Institute of Agricultural Research. 94 pp. [En.]

H. armigera was recorded in light traps at Holetta, Ethiopia only in late October and early November. At Melka Werer, it was observed almost throughout the year. (p. 36)

002 ARUNIN, A. (1978). Pests of soybean and their control in Thailand. pp 43-46. In: Singh, S.R., Van Emden, H.F. & Ajibola Taylor, T., (eds.) Pests of grain legumes: ecology and control. Academic Press, London. [En.]

States that large populations of H. armigera build up on tobacco and move to late soybeans once the tobacco has been harvested.

003 ATWAL, A.S., CHAUDHARY, J.P. & RAMZAN, M. (1969). Studies on the seasonal abundance of insects on light trap at Ludhiana. Journal of Research, Punjab Agricultural University, **6** (1) (Suppl.): 186-196. [En, en.]

Weekly light trap catches of H. armigera from 5 January 1966 to 26 October 1966 at Ludhiana, Punjab, India. Adults present from mid March to the first week of May with two peaks of activity in March and April.

004 BHATNAGAR, V.S. (1980). A report on research on Heliothis complex at ICRISAT (India), 1974-79. * Patancheru, Andhra Pradesh, India; International Crops Research Institute for the Semi-Arid Tropics, 23 pp. [En.] *Invited working paper presented at the All-India Workshop on Consolidation of Pest Management Recommendations and Guidelines of Research, session - Heliothis complex, Udaipur (India), 24-26 April 1980, under the auspices of the Entomological Society of India.

Light trap studies show catches of Heliothis spp are lowest when the moon is full with peaks in September, November/December and March/April. Females are more abundant in traps and catches higher near to a host crop. Migration indicated by large numbers of moths suddenly appearing in November and December 1977, probably aided by weather conditions. Observations using virgin female traps revealed that irrigation in groundnut and cowpea caused considerable increase in number of adults trapped.

005 BHATNAGAR, V.S. (1981). Entomological observations on intercropped pigeonpea in selected villages of Andhra Pradesh and Maharashtra (1977-1978). Patancheru, Andhra Pradesh, India; International Crops Research Institute for the Semi-Arid Tropics. (ICRISAT Cropping Systems (Entomology) [Departmental] Progress Report, no. 6.) 11 pp [En, en.]

Egg and larval counts on pigeonpea showed peak oviposition by H. armigera in October in Andhra Pradesh (at Aurepalle and Allapur) and in early December in Maharashtra (Kanzara). It is presumed that migration of moths from elsewhere was responsible for the high egg numbers and subsequent larval build up.

006 BHATNAGAR, V.S. (1981a). Farming Systems Research Program, Cropping Entomology, annual report of work, 1979-80. Patancheru, Andhra Pradesh, India; International Crops Research Institute for the Semi-Arid Tropics. (ICRISAT Cropping Entomology [Departmental] Progress Report no. 5) 22 pp. [En.]

Average annual light trap catches at ICRISAT Center during 1977-80 are given for H. armigera, H. assulta and H. peltigera. H. armigera was most abundant, with a peak catch in November. At Hissar, the highest catch was in September, with further peaks in December and February/March. Catches of H. armigera in sexlure traps are also recorded.

007 BHATNAGAR, V.S. & DAVIES, J.C. (1977). In-house review, cropping systems 1977, April 15 1977: cropping entomology. [Hyderabad], International Crops Research Institute for the Semi-Arid Tropics. 4 + [11] pp. [En.]

The "known migratory habit and powerful flight mechanism" of H. armigera are noted. Summary of 1977 light trap studies show; females are more numerous in a catch, catch effected by lunar cycle (lowest when full moon), three peaks of moth activity which have been displaced in different years, traps near crops collect greater moth numbers, and moths of all ages are trapped.

008 BHATNAGAR, V.S. & DAVIES, J.C. (1978). Factors affecting populations of gram pod borer, Heliothis armigera (Hübner) (Lepidoptera, Noctuidae) in the period 1974-77 at Patancheru (Andhra Pradesh). * Bulletin of Entomology, 19: 52-64. [En, en.] *Paper presented at the Workshop on the population ecology in relation to insects of economic importance, University of Agricultural Sciences, Bangalore (India), January 18-20, 1978.

Weekly totals of male and female H. armigera and their sex ratio at light trap in Patancheru, 1975-6, are given. Three peaks found per year, high numbers caught in November and December 1977. Evidence of possible migration is given.

009 BHATNAGAR, V.S. & DAVIES, J.C. (1978a). Cropping Systems Entomology, annual report 1975-76. Hyderabad, International Crops Research Institute for the Semi-Arid Tropics. ii + 56pp. [En.]

Monthly total light trap catches of H. armigera at the ICRISAT centre, 1974-6, are given. Positive relationship with lunar cycles giving lowest catch at full moon. Three peaks of moth numbers were recorded, in mid-September, mid November and a very high peak in March/April 1974-5. Trap catches found to be lower away from crops. Light trap data for Patancheru, October 1975 - January 1976, in relation to mean egg and larval numbers on intercropped pigeonpea, moon phase and rainfall are also shown. A peak was recorded in the latter half of December.

010 BHATNAGAR, V.S. & DAVIES, J.C. (1978b). Cropping Entomology, annual report 1976-77. Hyderabad, International Crops Research Institute for the Semi-Arid Tropics. ii + 11 pp. [En.]

Light trap records of H. armigera at 2 locations, ICRISAT Center, for October-January 1976/77 are given in relation to egg and larval counts on intercropped pigeonpea. Also, records from a third trap for August 1974 - May 1977 at the ICRISAT Center are plotted. Peaks occurred in September/October, November/December and April/May.

011 BHATNAGAR, V.S. & DAVIES, J.C. (1978c). Cropping Entomology, annual report 1977-78. Hyderabad, International Crops Research Institute for The Semi-Arid Tropics. (ICRISAT Cropping Entomology [Departmental] Progress Report no 1.) 11 + 30 pp. [En.]

Yearly light trap counts of H. armigera for 1974-78 at ICRISAT Center with hourly details for 6-12 December 1977 are given. An influx of 25,959 moths was recorded during December 1977, when it was suspected that weather conditions favoured migration of moths from elsewhere. Of all the females trapped in 1977, 80% were caught in the December period, the vast majority being virgin. An earlier indication of a suspected migration was observed on November 14th when 894 moths were caught. Data from light traps also given for a six-month period relating moth numbers to flower, egg and larval counts on pigeon pea.

012 BHATNAGAR, V.S. & DAVIES, J.C. (1980). Annual report, Cropping Entomology 1978-79. Patancheru, Andhra Pradesh, India; International Crop Research Institute for the Semi-Arid Tropics. (ICRISAT Cropping Entomology [Departmental] Progress Report no. 4.) 20 pp. [En.]

H. armigera records from 1 light trap at the ICRISAT Center during 1978-79 show that of 4,839 moths caught, 58% were female. Forty percent of the total catch, 46% of which were virgin, were trapped in December when it is suspected weather conditions favour influx from elsewhere. Catches for 1977 and 1978 are compared, the 1978 December peak being 14 times higher than in 1977. Catches from virgin female traps are also compared with light trap catches.

013 BHATNAGAR, V.S. & DAVIES, J.C. (1981). Entomological studies in intercropped pigeon pea systems at ICRISAT Center: future developments and collaborative research needs, pp 341-347 In: Kumble, V. (ed.), Proceedings of the International Workshop on Pigeonpeas, ICRISAT Center, Patancheru, India, 15-19 December 1980 Volume 2. Patancheru, Andhra Pradesh, India; International Crops Research Institute for the Semi-Arid Tropics. [En, en.]

Discusses a presumed winter immigration of Heliothis in some seasons into parasite study areas causing a disequilibrium with the native parasitic fauna.

014 BLATHWAYT, C.S.H. (1975). Migrant moths in South Cornwall in August 1974. Entomologist's Record and Journal of Variation, **87**(2): 58. [En.]

Record of one H. armigera near Downderry on 15th August.

015 BOGUSH, P.P. (1938). Some results of a study of insects by means of light traps in central Asia. Bulletin of Entomological Research, **27**: 377-380. [En.]

Observation of H. armigera at light in Bairam-Ali, Turkmenistan, in 1932.

016 BOURDOUXHE, L. (1980). Study of changes in Heliothis armigera flights with synthetic pheromone traps in Senegal. FAO Plant Protection Bulletin, **28**(3): 107-109. [En, en.]

Indicates activity of H. armigera throughout year in Cape Verde region by means of trap catches. Most active during February-April dry season with peaks in mid-February and end of March. During rainy season, mid-August-December, it disappeared, due to migration of populations to the cotton-producing areas of inland Senegal where crop is grown during July-November rainy season.

017 BOWDEN, J. (1970). Phenological analysis of African light-trap catches. Report of the Rothamsted Experimental Station, 1969 (1):241. [En.]

Unusually large catches of H. armigera on 5 and 6 January 1962 in Uganda in connection with unusual easterly incursion of mass of Congo air extending as far as western Kenya.

018 BOWDEN, J. (1973). Migration of pests in the tropics. Mededelingen van de Faculteit Landbouwwetenschappen Rijksuniversiteit Gent, **38**(3) part 1: 785-796. [En, en.]

Relates activity of Inter-Tropical Convergence Zone with migration of pests including H. armigera. Suggests connections between Heliothis on maize and cotton in East Africa and subsequent appearance in the cotton of the Sudan Gezira. The transport system which Heliothis appears to use moves regularly every year between the two areas.

019 BOWDEN, J. & CHURCH, B.M. (1973). The influence of moonlight on catches of insects in light-traps in Africa. Part II. The effect of moon phase on light-trap catches. Bulletin of Entomological Research, **63**: 129-142. [En, en.]

Correlates trap catches at Kawanda (Uganda) and Kwadaso (Ghana) with moonlight over a two year period. Changes in Heliothis catches with size of moon, and implies they are affected by illumination mostly in the second half of the night.

020 BOWDEN, J. & GIBBS, D.G. (1973). Light-trap and suction-trap catches of insects in the northern Gezira, Sudan, in the season of southward movement of the Inter-Tropical Front. Bulletin of Entomological Research, **62**: 571-596. [En, en.]

Trapping at Quwei, 50 miles south of Khartoum, was carried out from October to December during the period when movement of insects to cotton from other components of the Gezira rotation coincided with passage over the area of the Inter-Tropical Front. Light trapping confirmed earlier observations that H. armigera catches are very low when cotton is developing, September-December.

021 BOWDEN, J. & JOHNSON, C.G. (1976). Migrating and other terrestrial insects at sea. pp. 97-117 In: Cheng, L. (ed.) Marine Insects. Amsterdam, North Holland. xii + 581 pp. [En.]

Close association between arrival of H. armigera on Ascension Island and movement of frontal systems from south western Africa out over the Atlantic.

022 BOWDEN, J. & MORRIS, M.G. (1975). The influence of moonlight on catches of insects in light traps in Africa. III. The effective radius of a mercury-vapour light-trap and the analysis of catches using effective radius. Bulletin of Entomological Research, **65**: 303-348. [En, en.]

H. armigera was not very common in traps at Kawanda, Uganda. The catch curve shows a species flying very late at night with little if any activity before midnight. There does not appear to be a photo-periodic response but there may be some increase in activity and/or numbers in moonlit periods.

023 BRADER, L.M., BRADER, L., DELALANDE, P. & ATGER, P. (1968). Quatre années d'observations aux pièges lumineux en culture cotonnière au Tchad. [Four years of observations on light traps in cotton growing in Chad.] Coton et Fibres Tropicales, **23**(4): 469-475. [Fr, en, es, English version available.]

Light trapping data for 1965-1967 indicates that H. armigera disperses throughout a host field. Catches indicate that males and females are in equal numbers before midnight but that males predominate after midnight.

024 BRADER-BREUKEL, L.M. (1970). Lutte contre Diparopsis watersi (Roths.) et Heliothis armigera (Hb.). Attraction sexuelle et chimio-stérilisation. [Control of D. watersi (Roths.) and H. armigera (Hb.). Sexual attraction and chemosterilisation.] Coton et Fibres Tropicales, **25**(4): 505-508. [Fr, en, fr, es.]

Results showed H. armigera to be attracted to traps containing virgin females more readily in the 2 months before September than afterwards, in cotton in Chad.

025 BRETHERTON, R.F. (1982). Lepidoptera immigration to the British Isles, 1969 to 1977. Proceedings and Transactions of The British Entomological and Natural History Society, **15**(3/4): 98-110. [En.]

Records of sixteen H. armigera and three H. peltigera in 1969, four H. armigera in 1970, one H. armigera and a few H. peltigera larvae in 1971, and two H. peltigera in 1972.

026 BRETHERTON, R.F. & CHALMERS-HUNT, J.M. (1979). The immigration of Lepidoptera to the British Isles in 1978. Entomologist's Record and Journal of Variation, **91**(4): 81-91. [En.]

Date and place of capture of 14 H. armigera and 5 H. peltigera at light traps in the British Isles in October 1978. Likely origins and reasons for arrival are discussed.

027 BRIGGS, J. (1970). Some records of migrant lepidoptera in south Westmorland in 1969. Entomologist's Record and Journal of Variation, **82**(5): 135-136. [En.]

One female H. armigera found on wall near light trap two and a half miles from Silverdale. Only second recorded in N.W. England, first by Dr Burkett in Kendal on August 7th 1958.

028 BROWN, G.R. (1978). Light trapping of noctuid moths at Rydalmere, New South Wales [Australia]. General and Applied Entomology, **10**: 53-56. [En, en.]

Data for catches of H. armigera, H. punctigera and H. rubescens between June 1974 and June 1976. Comments on migration of H. punctigera, which was common, and the relatively non-migratory H. armigera, of which only 2 specimens were recorded. Both species were common in Windsor 30 km away.

029 CAYROL, R. (1965). Relations existant entre les migrations et le cycle évolutif de certaines espèces de Noctuidae (Insectes Lépidoptères). [Relationships existing between the migration and evolutionary cycle of certain Noctuid species.] Compte Rendu Hebdomadaire des Séances de l'Académie des Sciences, Paris, 260: 5373-75. [Fr, fr.]

H. peltigera among moths recognised to migrate to Great Britain. Results indicate that it is one of the species which migrates instead of undergoing diapause.

030 CAYROL, R., POITOUT, S. & ANGLADE, P. (1974). Étude comparée des caractères biologiques respectifs de quelques espèces de Noctuidae plurivoltines migrantes et sédentaires. I. Exposé des hypothèses de travail. Orientation des recherches entreprises. [Comparative study of biological characters pertaining to some multivoltine migratory and sedentary species of Noctuidae. I - Hypothesis of work. Trends of studies.] Annales de Zoologie - Écologie Animale, 6 (1): 1-10. [Fr, en, fr.]

Relationship between diapause and migration in nine species including H. armigera and H. peltigera. States that H. armigera is exception to the norm in that both diapause and migration can occur.

031 CHOI, K.M., CHO, E.H., SO, J.S. & HWANG, C.Y. (1975). [Studies on the seasonal occurrences of the tobacco budworm Heliothis assulta H. [sic] (Lepidoptera: Noctuidae), and the parasitism ratio of Trichogramma spp. on the eggs.] Korean Journal of Plant Protection, 14 (3): 137-140. [Ko, en.]

Seasonal fluctuations shown on red peppers in Suweon area of South Korea, data from black-light traps. Populations peaked in late June/mid-July, mid-to late August and in mid-September.

032 CIBA-GEIGY Seminar on the Strategy for Cotton Pest Control in the Sudan Gezira, 24-26 February 1975, Wad Medani, Sudan.

See : JOYCE, R.J.V. [?1975]
RAINEY, R.C. [?1975]
SCHAEFER, G.W. [?1975]

033 CIBA-GEIGY Seminar on the Strategy for Cotton Pest Control in the Sudan, 3rd, Basle, May 8-10, 1978.

See : HACKETT, D.[S.] & GATEHOUSE, A.G. [?1978]
JOYCE, R.J.V. [?1978]
TOPPER, C.[P.] [?1978]

034 CLASSEY, E.W. (1979). Scarce migrant Lepidoptera in Gloucestershire and Oxfordshire, October, 1978. Entomologist's Gazette, 30 (1): 72. [En.]

Record of H. armigera in England.

035 COMMONWEALTH INSTITUTE OF ENTOMOLOGY. (1951-). Distribution maps of pests. London, CIE. [Loose leaf binder; replacement and new maps issued.] [En.]

Map 15: H. armigera, map 262: H. assulta, map 263: H. punctigera.

036 DAVIES, J.C. (1975) Annual Report Entomology, 1974-1975. Hyderabad, International Crops Research Institute for the Semi-Arid Tropics. 54 + xvi pp. [En.]

H. armigera was caught in a light trap in every month of the year with peaks in late August/September, late October/December and a large peak in March. Catches were affected by lunar cycles, higher catches being made when no moon. Over the season higher catches were recorded than are quoted for many other tropical areas.

037 DAVIES, J.C. & LATEEF, S.S. (1975). Insect pests of pigeonpea and chickpea in India and prospects for control. pp 319-331. In: International Workshop on Grain Legumes, January 13-16, 1975, Hyderabad, India. Hyderabad, International Crops Research Institute for the Semi-Arid Tropics. [En.]

Notes that H. armigera is an active flier and is suspected of migrating on weather fronts. Refers to known and marked seasonal fluctuations in numbers.

038 DELOBEL, A. & GUTIERREZ, J. (1981). Fluctuations des captures de lépidoptères par piégeage lumineux, au cours d'une année, dans un biotope de Nouvelle - Calédonie. [Fluctuations in the catches of Lepidoptera in light traps in the course of a year in a biotope in New Caledonia.] Cahiers ORSTOM, série Biologie, **44**: 23-34. [Fr, en, fr.]

Three H. armigera conferta caught at light in three nights out of twelve. These were the only members of the Heliothinae caught despite the fact that this and other species were abundant in surrounding fields.

039 DRAKE, V.A., HELM, K.F., READSHAW, J.L. & REID, D.G. (1981). Insect migration across Bass Strait during spring: a radar study. Bulletin of Entomological Research, **71**(3): 449-466. [En, en.]

Insects, including H. punctigera, were observed to take off at dusk, and local movements from nearby islands to Tasmania were recorded on several occasions. Large-scale southward movements across the Bass Strait, originating mainly in Victoria and south-eastern South Australia but also probably westwards, were found to be associated with warm anticyclonic airflows occurring ahead of cold fronts.

040 DUGDALE, J.S. (1969). A note: some records of Australian Noctuidae in New Zealand. The New Zealand Entomologist, **4**: (2): 13-14. [En.]

Dates of capture of H. punctigera in mercury-vapour light traps at Opouri Valley and Ruakura in 1968.

041 EL-SAADANY, G. & ARD-EL-FATTAH, M.I. (1975). On the nocturnal flight activity of some species of Lepidoptera Injurious to cotton In Egypt. Anzeiger für Schädlingskunde, Pflanzenschutz und Umweltschutz, **48**: 109-110. [De, en.]

From ultra-violet light trap catches at Shebim El-khoum from July-August 1973 it was deduced that H. armigera is more active during the first half of the night. Flights decline from midnight onwards.

042 FOX, K.J. (1969). Recent records of migrant Lepidoptera In Taranaki. The New Zealand Entomologist, **4**(2): 6-10. [En, en.]

Records are given of H. punctigera caught in a mercury vapour light trap at Manala one mile inland from South Taranaki coastline, from September 1968 to February 1969, probably blown from Australia by two months of westerly gales.

043 FOX, K.J. (1970). More records of migrant Lepidoptera In Taranaki and the South Island. The New Zealand Entomologist, **4** (4): 63-66. [En, en.]

Records of H. punctigera at Lake Hawea and Wellington In 1969. Mentions inability of this species to overwinter In New Zealand.

044 FOX, K.J. (1970a). The Lepidoptera of the Egmont National Park. The New Zealand Entomologist, **4** (4): 30-38. [En.]

Record of single catch of H. armigera at 3,000 feet on South Egmont on 16.1.70.

045 FOX, K.J. (1973). Migrant Lepidoptera In New Zealand, 1971-1972. The New Zealand Entomologist, **5** (2): 143-146. [En.]

Sixteen H. punctigera recorded; several specimens taken in October after a week of strong north-westerly winds, followed later in the season by countrywide records in the absence of westerlies. Possible indication of breeding by the spring immigrants.

046 FOX, K.J. (1973a). Trans-oceanic dispersal of insects to New Zealand. The New Zealand Entomologist, **5** (3/4): 240-243. [En.]

Records of H. punctigera between 1968 and 1973. Suggests colonisation of New Zealand by H. punctigera possibly due to introduction of suitable host plants, as it is appearing in increasing numbers in the absence of strong winds.

047 FOX, K.J. (1973b). Migrant Lepidoptera In New Zealand 1972-1973. The New Zealand Entomologist, **5** (3/4): 268-271. [En.]

Records of H. punctigera in Manala and New Plymouth. States that there have been many records of this moth in Taranaki even in the absence of strong winds; author suspects establishment of the species in New Zealand.

048 FOX, K.J. (1975). Migrant Lepidoptera in New Zealand 1973-1974. The New Zealand Entomologist, **6**(1): 66-69. [En.]

Records of H. punctigera after north-westerly gales in October 1973. Notes that moths survived throughout summer.

049 FOX, K.J. (1978). The trans-oceanic migration of Lepidoptera to New Zealand. A history and a hypothesis on colonisation. The New Zealand Entomologist, **6**: 368-380. [En.]

Records H. punctigera as a definite migrant from Australia, showing numbers known to have bred in New Zealand, 1968-76. Migrations appear to occur after prolonged strong west to north-west winds.

050 FRENCH, R.A. (1953) Insect migration records, 1952. The Entomologist, **86** (7): 157-164. [En.]

Fifteen H. peltigera recorded in the British Isles in 1952.

051 FRENCH, R.A. (1954) Insect migration records 1953. The Entomologist, **87**: 57-63. [En.]

Sixteen H. peltigera recorded in the British Isles in 1953.

052 FRENCH, R.A. (1955). Migration records, 1954. The Entomologist, **88**: 123-130. [En.]

One H. peltigera and two H. armigera recorded in the British Isles in 1954.

054 FRENCH, R.A. (1956). Migration records, 1955. The Entomologist, **89**: 139-145 and 174-180. [En.]

Eighteen H. peltigera and two H. armigera recorded in the British Isles in 1955.

055 FRENCH, R.A. (1957). Migration records 1956. The Entomologist, **90**: 227-238. [En.]

Three H. peltigera and nine H. armigera recorded in the British Isles in 1956.

056 FRENCH, R.A. (1958). Migration records 1957. The Entomologist, **91**: 101-109. [En.]

Twenty-one H. peltigera and one H. armigera recorded in the British Isles in 1957.

057 FRENCH, R.A. (1959). Migration records, 1958. The Entomologist, **92**: 164-176. [En.]

One hundred and seven H. peltigera (a record year) and six H. armigera recorded in the British Isles in 1958.

058 FRENCH, R.A. (1962). Migration records, 1959. The Entomologist, **95**: 169-177. [En.]

Six H. peltigera and five H. armigera recorded in the British Isles in 1959.

059 FRENCH, R.A. (1962a). Migration records, 1960. The Entomologist, **95**: 204-211. [En.]

One H. peltigera and two H. armigera recorded in the British Isles in 1960.

060 FRENCH, R.A. (1963). Migration records, 1961. The Entomologist, **96**: 32-38. [En.]

Six H. armigera recorded in the British Isles in 1961.

061 FRENCH, R.A. (1964). Migration records, 1962. The Entomologist, **97**: 121-128. [En.]

One H. peltigera and ten H. armigera recorded in the British Isles in 1962.

062 FRENCH, R.A. (1965) Migration records, 1963. The Entomologist, **98**: 73-77. [En.]

One H. armigera recorded in the British Isles in 1963.

063 FRENCH, R.A. (1966). Migration records, 1964. The Entomologist, **99**: 233-240. [En.]

Twenty-six H. peltigera and four H. armigera recorded in the British Isles in 1964.

064 FRENCH, R.A. (1968). Migration records, 1965. The Entomologist, **101**: 156-161. [En.]

Five H. peltigera and four H. armigera recorded in the British Isles in 1965. Meteorological evidence suggest a wind-assisted passage for the former from the Canary Islands.

065 FRENCH, R.A. (1971). Migration records, 1966 and 1967. The Entomologist, **104**: 204-217. [En.]

Records one H. peltigera and two H. armigera in the British Isles in 1967; no Heliothis recorded in 1966.

066 FRENCH, R.A. (1973.) Migration records, 1968. The Entomologist, **106**: 256-263. [En.]

Seventy H. peltigera and six H. armigera recorded in the British Isles in 1968.

067 FRENCH, R.A. & HURST, G.W. (1969). Moth immigrations in the British Isles in July 1968. Entomologist's Gazette, **20**: 37-45. [En.]

H. peltigera and H. armigera recorded in England in June/July 1968 are thought to have been transported by wind from N.W. Spain or N. Africa.

068 GAGNEPAIN, C. (1974). Quantitative und qualitative Veränderungen einer Schmetterlingspopulation, beobachtet mit einer Lichtfalle während aufeinanderfolgender Jahre. [Quantitative and qualitative variations in a Lepidopteran population, observed with a light trap in successive years.] Folia Entomologica Hungarica, **27** (Suppl.): 129-141. [De.]

Catches from Jersey light trap in Yvette river valley, 25 km from Paris, placed 15 m above a roof terrace on the edge of a deciduous forest on a south facing valley slope. H. virescens taken in small numbers and only in certain years between 1965 and 1972.

069 GARDNER, A.F.J. (1977). Heliothis armigera scarce bordered straw. Entomologist's Record and Journal of Variation, **89**(3): 74. [En.]

Single female taken in mercury vapour trap in Charlesete, Warwick, England on 17th Oct.

070 GASKIN, D.E. (1970). Analysis of light trap catches of Lepidoptera from Palmerston North, New Zealand in 1966-68. New Zealand Journal of Science, **13**: 482-499. [En, en.]

Records of mercury vapour trap catches of H. armigera conferta and note on increased catch in 1967-68 compared with 1966-67.

071 GASKIN, D.E. (1970a). Migrant Lepidoptera recorded at Palmerston North, New Zealand, in 1968. The New Zealand Entomologist, **4**(3): 111-112. [En.]

Dates of capture of H. punctigera at light trap.

072 GLEDHILL, J.A. (1982). Progress and problems in Heliothis management in tropical southern Africa. pp 375-384 In: International Crops Research Institute for the Semi-Arid Tropics. Proceeding of the International Workshop on Heliothis Management, 15-20 November 1981, ICRISAT Centre, Patancheru, A.P., India. Patancheru, A.P., India; ICRISAT. [En, en, fr.]

Graphical comparisons of light trap records of H. armigera at Gatooma, Zimbabwe: 1971-72, a normal year; 1972-73, a drought year; 1975-76, cotton germination unusually late and 1980-81, an unusually wet year.

073 GORYSHIN, N.I. (1958). [The ecological analysis of the seasonal cycle of the development of the cotton bollworm (Chloridea obsoleta F.) in the northern areas of its range.] Scientific Memoirs of Leningrad State University, 240: 3-20. [Ru.]

Catch data of H. armigera (Chl. obsoleta), H. peltigera and H. virescens. Connects dispersal, photoperiod and temperature in a continental climate.

074 GREATHEAD, D.J. & GIRLING, D.J. (1982). Possibilities for natural enemies in Heliothis management and the contribution of the Commonwealth Institute of Biological Control. pp 147-158 In: International Crops Research Institute for the Semi-Arid Tropics. Proceedings of the International Workshop on Heliothis Management, 15-20 November 1981, ICRISAT Center, Patancheru, A.P., India. Patancheru, A.P., India; ICRISAT. [En, en, fr.]

"H. armigera and H. zea are known migrants of the northern fringe of their ranges but the degree to which they migrate elsewhere is controversial." But H. armigera may be more mobile than previously thought and possibly a partial migrant throughout its range. Considers that where H. armigera is migrant, biological control may be less easy and the likelihood of some natural enemies also migrating should also be explored.

075 HACKETT, D.S. (1980). [Unpublished] Studies on the biology of Helicoverpa armigera armigera (Hübner) in the Sudan Gezira. Ph.D thesis, University College of North Wales, Bangor. 184 pp [En, en.]

Migration not proven in the field but it is suggested that H.a. armigera is an opportunist species. Flight and reproductive behaviour consistent with H.a. armigera being a facultative migrant.

076 HACKETT, D.S. & GATEHOUSE, A.G. [1978]. Laboratory studies on adult flight behaviour and on pupal diapause in Heliothis armigera [Hb.]. pp 48-62 In: Third CIBA-GEIGY Seminar on the Strategy for Cotton Pest Control in the Sudan, Basle, May 8-10, 1978. Basle, CIBA-GEIGY. [En.]

Records of levels of flight activity; proposes that dispersal precedes oviposition and is probably due to food shortage at this time.

077 HACKETT, D.S. & GATEHOUSE, A.G. (1982). Studies on the biology of Heliothis spp. in Sudan. pp 29-38 In: International Crops Research Institute for the Semi-Arid Tropics Proceedings of the International Workshop on Heliothis Management, 15-20 November 1981, ICRISAT Center, Patancheru, A.P., India. Patancheru, A.P., India; ICRISAT. [En, en, fr.]

Long duration flight appears to be possible in H. armigera females under conditions which delay reaching reproductive maturity. Migration and diapause in H. armigera are thought to be facultative. At the end of the rainy season moth movement into the Gezira is feasible.

078 HAGGIS, M.J. (1981). Spatial and temporal changes in the distribution of eggs of Heliothis armigera (Hübner) (Lepidoptera: Noctuidae) on cotton in the Sudan Gezira. Bulletin of Entomological Research, **71** (2): 183-193 [En, en.]

Suggestion that redistribution of moth populations takes place over large distances.

079 HARDWICK, D.F. (1965). The corn earworm complex. Memoirs of the Entomological Society of Canada, **40**: 247 pp. [En.]

Reviews earlier records of apparent migration of H. armigera in Europe and South Africa. Suggests that migration may have evolved due to population pressures although some work suggests a genetic rather than environmental influence. Large key to literature concerning Helicoverpa complex.

080 HARIRI, G. (1982). The problems and prospects of Heliothis management in southwest Asia. pp 369-373 In: International Crops Research Institute for the Semi-Arid Tropics. Proceedings of the International Workshop on Heliothis Management, 15-20 November 1981, ICRISAT Center, Patancheru, A.P., India. Patancheru, A.P., India; ICRISAT. [En, en, fr.]

Reviews evidence for migration of H. armigera, H. virescens, H. peltigera and H. nubigera.

081 HASSANEIN, M.H. (1956). Nocturnal activity of insects as indicated by light-traps. Bulletin de la Société Entomologique d'Egypte, **40**: 463;479. [En, en.]

Record of sixty H. armigera being caught in traps at Shebin El-Kom, Egypt in 1952. In 1953 fifty eight were caught. Peak of activity was recorded during April and May.

082 HOU, W.W. & HO, S.W. (1979). [Studies on the phototactic behaviour of nocturnal moths: change in behaviour during the transformation of compound eyes.] Acta Entomologica Sinica, **22** (1): 34-40. [Ch, en.]

Catch data of H. armigera taken in light traps during light intensity experiments.

083 INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS. See also:

BHATNAGAR, V.S. (1980), (1981), (1981a)

BHATNAGAR, V.S. & DAVIES, J.C. (1977), (1978), (1978a), (1978b), (1978c), (1980), (1981)

DAVIES, J.C. (1975)

DAVIES, J.C. & LATEEF, S.S. (1975)

084 INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS (1976). Cropping Entomology. pp 178-187 In: ICRISAT annual report 1975-76. Hyderabad, International Crops Research Institute for the Semi-Arid Tropics. [En.]

Light trap records compared for H. armigera at ICRISAT Center trap no 1, 1974-75 and 1975-76. Three peaks of activity recorded; September, November/December and March/April; connected with oviposition on pigeonpea/sunflower, chickpea and tomato/maize respectively. More females than males were taken over the year. In 1975, nearly 50% of the total catch were trapped in April. Catches were lowest when the moon was full.

085 INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS (1981). Cropping Entomology, Farming Systems Research Program, Cropping Systems Subprogram: report of work, 1980-81. Patancheru, Andhra Pradesh, India; International Crops Research Institute for the Semi-Arid Tropics. (ICRISAT Cropping Systems (Entomology) [Departmental] Progress Report, no. 8.) [iii] + 50 + [xviii] pp. [En.]

Light trap catch records of H. armigera at Vertisol watersheds ICRISAT Center, 1977-81 given. Records for 1980/81 at 3 different locations, Patancheru, Hissar & Dharwad show three major peaks of activity. Peaks associated with pulses were in February/April in Northern India (Hissar) and October/December at Patancheru and Dharwad. Peak times of nightly catches given for; sticky traps baited with virgin females (2300 hrs - 0500 hrs), sticky traps with pheromone rubber septa (1800 - 0500 hrs) and light traps (0000 - 0500 hrs).

086 INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS. (1982). Proceedings of the International Workshop on Heliothis Management, 15-20 November 1981, ICRISAT Center, Patancheru, A.P., India. Patancheru, A.P., India; ICRISAT. [En.]

See : GLEDHILL, J.A. (1982)

GREATHEAD, D.J. & GIRLING, D.J. (1982)

HACKETT, D.S. & GATEHOUSE, A.G. (1982)

HARIRI, G. (1982)

RAULSTON, J.R. (1982)

RAULSTON, J.R., WOLF, W.W., LINGREN, P.D. & SPARKS, A.N. (1982)

087 JOYCE, R.J.V. (1973). Insect mobility and the philosophy of crop protection with reference to the Sudan Gezira. PANS, **19** (1): 62-70. [En.]

A definite pattern of distribution noted for H. armigera over thousands of square kilometres possibly determined by transport and concentration by major windfields including the Inter Tropical Front.

088 JOYCE, R.J.V. [1975] The implications to control strategy of the observed flight activity of pest species in the Sudan Gezira. 15 pp In: CIBA-GEIGY Seminar on the Strategy for Cotton Pest Control in the Sudan Gezira, [1st], 24-26 February, 1975. Wad Medani, Sudan. Wad Medani, Sudan, CIBA-GEIGY. [En.]

Heliothis moths' strong flight indicated by observations of day and night 'short' movements. Total adult population evacuates crop fields, used for daytime cover, soon after sunset. Distances given for possible movements in various wind directions and concludes that movements and areas of immigration determined primarily by winds in which moths fly. Mass invasions from exterior probably do not occur but egg count peaks and troughs are due to windborne distribution, any infestations due to concentration of windborne insects deposited on fields. Flight activity of Heliothis in Gezira very much in common with large number of species that use the lower 50 m of atmosphere in the early evening.

089 JOYCE, R.J.V. (1976). Insect flight in relation to problems of pest control pp. 135-155 In: Rainey, R.C. (ed.) Insect flight. Oxford, Blackwell. (Symposia of The Royal Entomological Society of London: number seven.) 287 pp [En.]

Reviews the evidence that the origins of successive invasions of H. armigera into cotton in the Sudan Gezira may be local or distant, and the intensity light or heavy depending on the wind-systems transporting or condensing them.

090 JOYCE, R.J.V. [?1978]. The strategy of cotton pest control in the Sudan Gezira. pp 85-103 In: Third CIBA-GEIGY Seminar on the Strategy for Cotton Pest Control in the Sudan, Basle, May 8-10, 1978. Basle, CIBA-GEIGY. [En, en.]

States that 95% of H. armigera eggs deposited on cotton are laid by moths originating on other crops. Important pests of cotton are not only exploiters of unstable environments but they also show a high level of migratory activity.

091 JOYCE, R.J.V. (1982). A critical review of the role of chemical pesticides in Heliothis management. pp 173-188 In: International Crops Research Institute for the Semi-Arid Tropics. Proceedings of the International Workshop on Heliothis management, 15-20 November 1981, ICRISAT Center, Patancheru, A.P. India. Patancheru, A.P., India; ICRISAT. [En, en, fr.]

States that Heliothis spp. are highly mobile. Availability of food determines activity. Where larvae originate from a poor food supply long flights are recorded whereas shorter flights are made by moths originating from good food supplies. Flights in the Sudan Gezira recorded from groundnuts to a flowering legume for nectar, then to cotton for oviposition and back to groundnuts for day-time resting.

092 KAO, W.-t. (1980). Studies on the phototactic behaviour of nocturnal moths: analysis of the causes of flight towards a lamp. Acta Entomologica Sinica, **23**(4): 369-373. [Ch, en.]

Trap catches of H. armigera.

093 KEHAT, M., GOTHILF, S., DUNKELBLUM, E. & GREENBERG, S. (1980). Field evaluation of female sex pheromone components of the cotton bollworm Heliothis armigera. Entomologia Experimentalis et Applicata, **27**(2): 188-193. [En, fr.]

Trapping experiments and comparative records for synthetic and natural pheromones, May-September, 1978 at Givat-Brenner, Israel.

094 KEHAT, M., GOTHILF, S., DUNKELBLUM, E. & GREENBERG, S. (1982). Sex pheromone traps as a means of improving control programs for the cotton bollworm, Heliothis armigera (Lepidoptera: Noctuidae). Environmental Entomology, **11**(3): 727-729. [En, en.]

Synthetic pheromone trap used to monitor adult populations at six locations in Israel. Records of population variation with months, April to September 1980, and between the different sites. Evidence for migration into cotton fields. No effect from moon upon trap count.

095 KETTLEWELL, H.B.D. (1970). Migratory and other captures, Steeple Barton, Oxfordshire, 1968-69. Entomologist's Record and Journal of Variation, **82**(5): 138-140. [En.]

One H. armigera male taken at mercury vapour light trap on 26 May 1969.

096 KEYNAS, K. (1968). Arenostola brevilinea Fenn and Heliothis armigera [Hb.] (Lep., Noctuidae) found in Finland. Annales Entomologici Fennici **34**(3): 170-173. [En.]

One male H. armigera caught at light in Southern Finland in September 1967. First record in this country and a probable immigrant from south west Soviet Union, carried by air currents.

097 KIRKPATRICK, T.H. (1961). Queensland distributions and host records for Heliothis species (Lepidoptera: Noctuidae) Queensland Journal of Agricultural Science, **18**: 195-202. [En.]

Maps distribution of H. armigera, H. rubescens, H. assulta and H. punctigera from larval counts and light trap records.

098 KRAVCHENKO, V.D. (1981). Interrelations between flight to light and mobility in the cotton bollworm (Helicoverpa armigera). Zoologicheskii Zhurnal, **60** (8): 1267-1269. [Ru, en.]

Catches made at Azerbaidzhan and Zardobsk in USSR in September 1979. Traps two metres above cotton crop. Data shows difference between male and female activity at this time.

099 KRAVCHENKO, V.D. (1981a) The nocturnal activity of cotton owlet moths (Helicoverpa armigera). Zoologicheskii Zhurnal, **60**(11): 1640-1644. [Ru, en.]

Light and virgin female trap catches in Zardobsk region of Azerbaidzau, USSR, August-September 1979.

100 LASEBIKAN, B.A. (1982). Seasonal distribution and diversity of noctuid moths on the University of Ife campus. Insect Science and its Application, **3**(1): 43-47 [En, en.]

Records ten H. assulta and three H. armigera caught in mercury vapour light trap run once a month from November 1976 to October 1977 at Ile-Ife, Nigeria.

101 LEE, H.Y. & CHOI, C.I. (1975). Population fluctuations of oriental tobacco budworm (Heliothis assulta G.) in blacklight traps and field control studies. Research Report, Office of Rural Development Suweon Horticulture and Agricultural Engineering, **17**: 25-31. [Ko, en.]

Records of H. assulta taken between early June and mid-October for three consecutive years in Korea.

102 LEMPKE, B.J. (1977). Trekvlinders in 1975 [Migratory butterflies in 1975] Entomologische Berichten, **37**(1): 1-5. [Nl, en.]

One H. armigera taken on July 10th in the Netherlands, first record since 1962.

103 MORTON, R., TUART, L.D. & WARDHAUGH, K.G. (1981). The analysis and standardization of light-trap catches of Heliothis armiger[a] (Hübner) and Heliothis punctiger[a] Wallengren (Lepidoptera, Noctuidae). Bulletin of Entomological Research, **71**(2): 207-225. [En, en.]

Analysis of hourly and nightly catches of H. armigera and H. punctiger near cotton in Namoi Valley, New South Wales in relation to environmental factors (wind speed, temperature, night length and moonlight). Three discrete periods of abundance of H. armigera but H. punctiger was abundant only during first half of season.

104 MYERS, A.A. (1981). Migrant nocturnal Lepidoptera in Co Cork, 1971-1980. A review. Irish Naturalists' Journal, **20** (7): 301-302. [En.]

One H. armigera recorded in Fountainstown in 1978, the first Irish record of this moth.

105 NEL, J.J.C. (1961). The seasonal history of Heliothis armigera (Hüb.) on lupins in the south western Cape Province. South African Journal of Agricultural Science, **4**(4): 575-588. [En, en, af, fr.]

Discussion of possible migration of H. armigera 45 miles south from Ollifant's River settlement, where it is present all year, to Graafwater in the Sandveld in Spring. There may also be immigration from the south.

106 NOVAK, I. & SPITZER, K. (1972). The relationship between migration and diapause during phylogeny and ontogeny of some Lepidoptera. Journal of Research on the Lepidoptera, **10** (2) 181-184. [En.]

Discussion of different kinds of migration-diapause relationships placing H. peltigera as migratory non-diapause. Populations in Central and Northern Europe are renewed by migrations every year.

107 ODIYO, P.O. (1977). The use of Insect light traps for monitoring changes in the distribution of crop pests in E. Africa. pp 102-106 In: Lima, C.P.F. De (ed.), Advances in medical, veterinary and agricultural entomology in eastern Africa. Proceedings of the 1st E.A. Conference on Entomology and Pest Control, December 6-10, 1976, Nairobi, Kenya. Nairobi, East African Literature Bureau. [En.]

Occurrence of H. armigera at light traps at Muguga, Kenya, in 1972, 1974 and 1976, peaking in May every year.

108 OKU, T. & KOBAYASHI, T. (1978). Migratory behaviors and life-cycle of noctuid moths (Insecta, Lepidoptera) with notes on the recent status of migrant species in northern Japan. Bulletin of the Tohoku National Agricultural Experimental Station, **58**: 97-209. [Ja, en.]

Connection between non-diapause and seasonal migration in H. peltigera and H. armigera and rare occurrences of the latter in Northern Japan due to immigration from the south.

109 OTAKE, A. OYAMA, M & HATTORI, I. (1974). A study on Noctuidae captured by Spodoptera litura virgin female traps. Bulletin of the Shikoku Agricultural Experiment Station, **28**: 65-74. [En, en, Ja.]

One male and two female H. assulta caught in blacklight traps in July and August respectively in 1971 in Japan. No Heliothidinae taken in pheromone trap.

110 PAL, S.K. & SACHAN, J.N. (1979). The relative abundance of photo-positive insects at Central Arid Zone Research Institute Farm, Jodhpur (Raj.). Proceedings of the Indian National Science Academy, B, **44** (1978) (6): 357-363. [En, en.]

Light trap catches in 1971-1972 showed Lepidoptera to be present from April-November in 1971 with peaks during April and August-September. In 1972, moths were observed throughout the year with peaks during July-October and April. Noctuids including H. armigera were the most heavily represented but no details are given.

111 PALMQVIST, G. (1981). Intressanta fynd av Macrolepidoptera i Sverige 1980. [Interesting finds of Macrolepidoptera in Sweden in 1980.] Entomologisk Tidskrift, **102** (2/3): 99-104. [Sv, en.]

List of rare migrants including H. peltigera.

112 PARSONS, F.S. (1939). Investigations on the cotton bollworm, Heliothis armigera [Hübner] (obsoleta, [Fabricius]), Part 1 - The annual march of bollworm incidence and related factors. Bulletin of Entomological Research, 30: 321-339. [En, en.]

No evidence of moth migrations across the regions of South Africa.

113 PATIL, B.V., DEVAIAH, M.C. & THONTADARYA, T.S. (1981). Nocturnal activity of some important Lepidopterous pests at light-traps. Indian Journal of Ecology, 8 (2): 253-258. [En, en.]

Studies of H. armigera at Dharwad, Karnataka State, showed the moth to be attracted to light in differing quantities at different periods of the night, the maximum catch being from 10 pm to 2 am. More males were attracted to the trap from 12 pm to 2 am whereas more females were trapped from 8-12 pm.

114 PERSSON, B. (1976). Influence of weather and nocturnal illumination on the activity and abundance of populations of noctuids (Lepidoptera) in south coastal Queensland. Bulletin of Entomological Research, 66(1): 33-63. [En.]

Effects of nocturnal illumination, night temperature and night wind on nocturnal distribution of H. armigera and H. punctigera over 18 month period. Strong indication of migration of H. punctigera in autumn of 1973, moths probably entering the area during nights with wind convergence caused by the passage of cold fronts.

115 PERSSON, B. (1977). Distribution of catch in relation to emergence of adults in some noctuid pest species in south coastal Queensland. Australian Journal of Zoology, 25 (1): 95-102. [En.]

Not certain whether H. armigera and H. punctigera are part of local (Samford) noctuid fauna but strong indications that moths captured at Samford were caught when they flew into the area and did not belong to local populations.

116 POITOUT, S. & BUES, R. (1979). La noctuelle de la tomate (Heliothis ou Helicoverpa armigera [Hbn.]). Son cycle évolutif dans le sud de la France. [Tomato fruitworm Heliothis armigera [Hbn.] [Lepidoptera: Noctuidae] Its life cycle in southern France] La Défense des Végétaux, 195: 12-28. [Fr, fr, en.]

Light trap studies and population surveys of H. armigera in Southern France indicate probable migrations into areas where overwintering impossible.

117 POITOUT, S., CAYROL, R., CAUSSE, R. & ANGLADE, P. (1974). Déroulement du programme d'études sur les migrations de lépidoptères Noctuidae réalisé en montagne et principaux résultats acquis. [The progress of a programme of studies on the migrations of Noctuid moths carried out in mountainous country and the principal results obtained.] Annales de Zoologie Ecologie et Animale, 6 (4): 585-587. [Fr, en, fr.]

Migratory flights of some species of Noctuidae have been observed in France since 1968. H. armigera & H. peltigera are found in the Pyrenees while the latter is also found to a lesser extent in the Alps.

118 POLTAVSKII, A.N. & RYBIN, S.N. (1980). [Moths (Lepidoptera, Noctuidae) of Northern Ossetia.] Entomologicheskoe Obozrenie, **59** (1): 98-106. [Ru, en.]

H. armigera and H. imperialis were caught in light traps during a survey carried out between 1976 and 1978 in the Caucasus Mts, USSR.

119 POPOV, P. & IOSIFOVA, K. (1978). Studies on Noctuid moths (Noctuidae) by the method of light attracting. I Species composition. Rasteniev'Dni Nauki, **15** (8): 131-143. [Ru, en.]

Records catches of H. virescens, H. peltigera, H. armigera, and H. incarnata for 1969-1975 in Kostinbrod, Bulgaria.

120 RAINEY, R.C. [?1975] Heliothis outbreaks in the Sudan Gezira as indicated by egg infestations and their relationship to transport and concentration of airborne moths in wind-fields. 1p in: CIBA-GEIGY Seminar on the Strategy for Cotton Pest Control in the Sudan Gezira, [1st.], 24-26 February 1975, Wad Medani, Sudan. Wad Medani, Sudan, CIBA-GEIGY. [En.]

Conclusions from egg counts and wind and weather studies suggest that Heliothis infestations may be due to series of discrete populations moving within specific areas of up to 1000s of square kilometres for several days at a time. Successive days counting data (not shown) display a close correlation in the majority of cases.

121 RAINEY, R.C. (1976). Flight behaviour and features of the atmospheric environment. pp 75-112 in: Rainey, R.C., (ed.), Insect flight. Oxford, Blackwell. (Symposia of the Royal Entomological Society of London: number seven.) 287 pp [En.]

Indication of association of high light-trap catches of H. armigera with incursions of westerly winds into Nairobi area, Kenya.

122 RAULSTON, J.R. (Discussion leader.) (1982). Surveillance, forecasting, and modeling of Heliothis populations. pp 402-404 in: International Crops Research Institute for the Semi-Arid Tropics, Proceedings of the International Workshop on Heliothis Management, 15-20 November 1981, ICRISAT Center, Patancheru, A.P., India. Patancheru, A.P., India; ICRISAT. [En.]

States that annual migration of Heliothis in USA confirmed but there is less evidence for long-range migration in H. armigera. Discusses techniques used in movement studies.

123 RAULSTON, J.R., WOLF, W.W., LINGREN, P.D. & SPARKS, A.N. (1982). Migration as a factor in Heliothis Management. pp 61-73 in: International Crops Research Institute for the Semi-Arid Tropics, Proceedings of the International Workshop on Heliothis Management, 15-20 November 1981, ICRISAT Center, Patancheru, A.P., India. Patancheru, A.P., India; ICRISAT. [En.]

A review. All the papers considered are listed in this bibliography. Authors conclude that although plenty of evidence for long-range movement is available, no direct evidence for a migration from one habitat to another has yet been obtained.

124 REED, W. (1965). *Heliothis armigera* (Hb.) (Noctuidae) in western Tanganyika. II - Ecology and natural and chemical control. Bulletin of Entomological Research, **56**: 127-140. [En, en.]

Light trap data for Ukiriguru, December 1961-September 1964 show population peaks in April 1962, June 1963 and March 1964.

125 RIVNAY, E. (1962). The African cotton bollworm - *Heliothis armigera* (Hb.). pp 119-125 In: Rivnay, E., Field crop pests in the Near East. The Hague, Junk Publishers. (Monographiae Biologicae, volume 10) [En.]

States "It is an established fact which needs no further evidence that *H. armigera* and *H. peltigera* are migrants like their related *H. zea* in America" and cites as evidence invasion of crops on virgin land in the Negev, Israel, by a pest that was never known there before.

126 ROBERTSON, I.A.D. (1977). Records of insects taken at light traps in Tanzania. VII - Seasonal changes in catches and effect of the lunar cycle on the adults of several pest species of Lepidoptera (Lepidoptera: Noctuidae.) London, Centre for Overseas Pest Research. (Miscellaneous Report, no. 38.) 11 pp. [En.]

Records of *H. armigera* taken in light traps correlated with rainfall at six sites 1963-7. Some evidence in some areas for migration but not conclusive.

127 ROOME, R.E. (1971). Field studies of the biology of *Heliothis armigera* (Hb.) (Lepidoptera: Noctuidae) in Botswana. pp 32-46 In: Cotton Insect Control, Proceedings of the Cotton Insect Control Conference held Blantyre, Malawi, March 24-27, 1971. Thonwe, Agricultural Research Council of Malawi. [En, en.]

Robinson light trap data for *H. armigera* and *H. scutigerana*, August 1968-June 1970.

128 ROOME, R.E. (1972). Annual Report 1971-72. Entomologist: ODA Botswana Dryland Farming Research Scheme. ODA, Botswana Dryland Farming Research Scheme (R. 2420). Report, 1972. London, Overseas Development Administration. [62] pp. [En.]

Fluctuations of adult *Heliothis* populations from mercury-vapour light trap data, suspected migration, dates of large catches and evidence for migration.

129 ROOME, R.E. (1973). Dryland Farming Research Scheme. Second Annual Report: 1972-73 Entomology: ODA, Botswana Dryland Farming Research Scheme (R. 2420). Report 1973. Gaborone Agricultural Research Station. 52 pp. [En.]

Analysis of mercury-vapour light trap data and implications for migration of *H. armigera* from Rhodesia.

130 ROOME, R.E. (1974). Dryland Farming Research Scheme: Botswana (ODA Research Scheme R. 2420) Entomological research 1970-1973. Summary report and recommendations. London, Overseas Development Administration. [3] + 20 pp. [En.]

Records of light trap catches and rainfall, 1968-73, comment on adult H. armigera movement and winds.

131 ROOME, R.E. (1975). The biology and biological control of Heliothis armigera [Hb.] (American Bollworm). pp. 19-62 In: Crop protection in Botswana biennial report 1969-71. Gaborone, Agricultural Research Station. 112 pp [En.]

Section on climate, adult population changes and larval infestations; also light trap data.

132 ROOME, R.E. (1975a). Activity of adult Heliothis armigera (Hb.). (Lepidoptera, Noctuidae) with reference to the flowering of sorghum and maize in Botswana. Bulletin of Entomological Research, **65** (3): 523-530. [En, en.]

Light-trap and hand net catches for H. armigera in sorghum and maize in 1973.

133 ROOME, R.E. (1975b) The control of Heliothis on subsistence crops in Botswana. Mededelingen van de Faculteit Landbouwwetenschappen Rijksuniversiteit Gent, **40**: 267-282. [En, en.]

Details of adult movements and light trap catches, 1971-72. Evidence for movement of H. armigera over very great distances and association with incoming storms. Probable that winds from Rhodesia and South Africa carried H. armigera into Botswana.

134 ROOME, R.E. (1976). The biology and biological control of Heliothis armigera [Hb.] (American Bollworm). p10-111 In: Crop protection in Botswana biennial report 1971-73. Gaborone, Agricultural Research Station. [En.]

Contains sections concerning climate and adult population changes (including migration and light trap data). Evidence and dates for suspected H. armigera migration.

135 ROTHSCHILD, G.H.L. (1978). Attractants for Heliothis armigera and H. punctigera. Journal of the Australian Entomological Society, **17** (4): 389-390 [En.]

Comparison of light trap and sex-attractant trap catches of the two species in New South Wales, 1977

136 ROTHSCHILD, G.H.L., NESBITT, B.F., BEEVOR, P.S., CORK, A., HALL, D.R. & VICKERS, R.A. (1982). Studies of the female sex pheromone of the native budworm, Heliothis punctigera [L]. Entomologia Experimentalis et Applicata, **31**(4): 395-401. [En, fr.]

Comparative records of H. punctigera taken at traps containing different sex attractants, 1978-81, New South Wales, Australia.

137 SCHAEFER, G.W. [?1975]. Radar studies of the flight activity and the effects of windfields on the dispersal of Sudan Gezira insects. 20 pp + 34 pp tables, figs, graphs etc. In: CIBA-GEIGY Seminar on the Strategy for Cotton Pest Control in the Sudan Gezira, [?1st] 24-26 February 1975, Wad Medani, Sudan. Wad Medani, Sudan, CIBA-GEIGY. [En.]

Information about general moth populations and the effects of the Inter-Tropical Front upon their dispersal. H. armigera among chief species at light trap (data presented) but not proven to be in the radar echoes. Comments about probability of migration and strong flight in this moth.

138 SCHAEFER, G.W. (1976). Radar observations of insect flight. pp. 157-197 In: Rainey, R.C., (ed.), Insect flight. Oxford, Blackwell. (Symposia of the Royal Entomological Society of London: number seven.) 287 pp [En.]

Mentions sightings of H. armigera taking off in plumes and rising to 150-200 m before diffusing, in Sudan Gezira.

139 SINGH, H. & SINGH, G. (1975). Biological studies on Heliothis armigera in the Punjab India. Indian Journal of Entomology, **37**(2): 154-164. [En, en.]

Light trap catches over a year showed a peak in April with a smaller one in August.

140 TALHOUK, A.M.S. (1969). Insects and mites injurious to crops in Middle Eastern countries. Monographien zur Angewandte Entomologie, **21**: 239 pp. [En.]

States that H. armigera (pp 192-3) is known to be migrant. The moth may fly to the Eastern Mediterranean from the warmer parts of Africa.

141 TAYLOR, J.S. (1932). Notes on the American bollworm (Heliothis obsoleta, [Fabr.]) on cotton, and on its parasite Microbracon brevicornis Wesm. South Africa Department of Agricultural Science Bulletin, **113**: 1-10. [En.]

Has been found to be very difficult to obtain definite proof of long-distance migrations of H. armigera (H. obsoleta) in South Africa, but evidence for migration over shorter distances eg. of about three quarters of a mile.

142 TAYLOR, L.R. & BROWN, E.S. (1972). Effects of light-trap design and illumination on samples of moths in the Kenya highlands. Bulletin of Entomological Research, **62**: 91-112. [En, en.]

Records of H. armigera taken in three different traps at Muguga, Kenya in 1968.

143 TOPPER, C.[P.] [?1978]. The incidence of Heliothis armigera larvae and adults on groundnuts (and sorghum) and the prediction of oviposition on cotton. pp 17-33 In: Third CIBA-GEIGY Seminar on the Strategy for Cotton Pest Control in the Sudan, Basle, May 8-10, 1978. Basle, CIBA-GEIGY. [En.]

Black-light trap records of night-time ovipositing females and daytime preoviposition females August-October 1977. Moths probably migrate from groundnuts to cotton in Sudan Gezira.

144 TOPPER, C.P. (1981). The behaviour and population dynamics of *Heliothis armigera* (Hb.) (Lepidoptera, Noctuidae) in the Sudan Gezira. Volume 1. Ph.D. thesis, Cranfield Institute of Technology, Ecological Physics Research Group. 300 pp. [En, en.]

Studies carried out in the Sudan Gezira (1975-8) failed to show any long distance movement by *H. armigera*. Moths did not leave the boundary layer in significant numbers and therefore could only undergo limited distribution. Light traps operated at canopy height and 15 m above that level showed little activity at 15 m. Aircraft sampling over the Gezira failed to catch any *H. armigera* except in 1977 when two were caught. Monthly inter-crop movements shown for groundnut, sorghum and cotton.

145 VAISHAMPAYAN, S.M. (1980). Seasonal abundance and activity of gram pod borer moths *Helicoverpa (Heliothis) armigera* (Hübner) on light trap equipped with mercury vapour lamp at Jabalpur. Indian Journal of Ecology, 7 (1): 147-154. [En, en.]

Studies in the period June 1974 to May 1978 showed *H. armigera* to be most active between January and May and least active between June and October. Increased activity occurred in November especially in years suited to pest development. Monthly light trap results and weekly distributions are given, sudden peaks in March, April and May indicating either long distance migration or delayed emergence due to diapause within the population.

146 VERMEULEN, J.B. (1973). The occurrence and abundance of *Heliothis assulta afra* (Hardwick) in light traps in South Africa (Lepidoptera: Noctuidae). Journal of the Entomological Society of Southern Africa, 36 (2): 309-310. [En.]

Records of *H. assulta afra* at 11 sites in the Transvaal and one in Natal in 1971-2. Comments on more common and easily confused *H. armigera*. *H. assulta afra* was most abundant in December-April.

147 VERMEULEN, J.B. (1976). [Unpublished] Aspects of the ecology of *Heliothis armigera* (Hübner) in South Africa based on light trap catches. Ph.D thesis, University of Pretoria. ix + 395 pp. [En, en.]

Light trap records of *H. armigera* at several sites in South Africa, 1970-74. Records also of *H. assulta afra* and *H. xanthiata*. Sudden population increases and decreases could not be accounted for from temperature and rainfall data. Evidence sought for migration but no direct evidence found although indication that large scale weather disturbances may influence size of catch.

148 VERMEULEN, J.B. & CATLING, H.D. (1980). Establishment of a grid of light-traps in South Africa and some preliminary results for the Noctuidae. Phytophylactica, 12 (2): 31-43. [En, en, af, fr.]

Details of light trap grid and monthly mean catches of *H. armigera*, 1970-72, at all six sites.

149 WARDHAUGH, K.G., ROOM, P.M. & GREENUP, L.R. (1980). The incidence of Heliothis armigera (Hübner) and H. punctigera Wallengren (Lepidoptera: Noctuidae) on cotton and other host-plants in the Namoi Valley of New South Wales. Bulletin of Entomological Research, 70: 113-131. [En, en.]

Four years of light trap data presented, 1974-8. No evidence for regular patterns of large-scale seasonal movements.

150 WILSON, A.G.L. [1982] Past and future Heliothis management in Australia. [Narrabri, Australia, Commonwealth Scientific and Industrial Research Organisation Division of Plant Industry, Cotton Research Unit.] 21 pp. [En.]

Discusses migratory habit of H. punctigera; states that H. armigera is a more sedentary pest in Australia although intercrop movements are thought to occur.

151 WILTSHIRE, E.P. (1957). The Lepidoptera of Iraq. London, Nicholas Kaye. 162 + 36 pp [En.]

Describes populations of H. viriplaca, H. peltigera, H. nubigera and H. armigera. H. viriplaca may be migratory whilst H. peltigera and H. nubigera are definitely so.

152 YATHOM, S. (1971). Distribution and flight period of Heliothidinae species in Israel in 1959-69. Israel Journal of Agricultural Research, 21 (2): 51-61. [En.]

Four species of Heliothis were caught at light-traps in four regions of Israel. Marked fluctuations in populations of H. peltigera within and between years suggest migration and invasion from outside. H. nubigera is a known migrant, probably invading Israel annually from a breeding centre in the south. The yearly increases in H. armigera populations appear to be of local origin. H. viriplaca is a local resident. No evidence of it being a migrant or partly migratory.

NEW WORLD

153 ANONYMOUS. (1975). The moths that went to sea. Agricultural Research, **24** (1): 12-13. [En.]

Review and discussion of Sparks, A.N., Jackson, R.D. & Allen, C.L. (1975).

154 BAUST, J.G., BENTON, A.H. & AUMANN, G.D. (1981). The influence of off-shore platforms on insect dispersal and migration. Bulletin-Entomological Society of America, **27** (1): 23-25. [En.]

Thirteen H. virescens were taken in a random collection on an oil platform in the Gulf of Mexico, 160 km south-south east of Galveston, Texas, on October 1-2 1978. Sample only 0.1% of total number on platform. Platforms in this area are brightly lit and at a density of about one per six-square miles. It is suggested that the offshore platform complex may serve as an insect migration route offering "rest stops" and sources of fresh water. It may also act as a new mode of introduction of non-native species into the continental U.S., providing a chain which facilitates insect movement.

155 BECKHAM, C.M. (1970). Seasonal abundance of Heliothis spp. in the Georgia Piedmont. Journal of the Georgia Entomological Society, **5**: 138-142 [En, en.]

Monthly results of light trap studies in Spalding County during 1965-1969 for H. zea and H. virescens.

156 BEIRNE, B.P. (1971). Pest insects of annual crop plants in Canada. I. Lepidoptera, II Diptera, III Coleoptera. Memiors of the Entomological Society of Canada, no. 78: 124 pp. [En.]

States that H. zea is a strong flying immigrant from the south. Moth flights into Nova Scotia have been encouraged by a hurricane and by an unusual preponderance of southerly winds in July.

157 BIRD, R.D. (1937). Records of northward migration of southern insects during drought years. Canadian Entomologist, **69** (5): 119-120. [En.]

An unusual number of H. zea recorded near Brandon, Manitoba, in 1934.

158 BLANCHARD, R.A. (1942). Hibernation of the corn earworm in the Central and Northeastern parts of the United States. United States Department of Agriculture, Technical Bulletin, no. 838: 13 pp. [En, en.]

Circumstantial evidence suggests migrations of H. zea into the North Central States in years when southern crops were effected by drought - eg. 1936. Lack of survival in hibernation experiments in the north suggests that most bollworms, both small annual populations and occasional large infestations, are due to immigrations governed by conditions in the southern states.

159 CALLAHAN, P.S., SPARKS, A.N., SNOW, J.W. & COPELAND, W.W. (1972). Corn earworm moth: vertical distribution in nocturnal flight. Environmental Entomology, **1** (4): 497-503. [En, en.]

Short review of insect dispersal and catches by aeroplane. Blacklight traps placed at various points on a television tower, in Georgia, between 25 and 1047 feet, only visible from above, collected insects between August 4 and November 9, 1967 and 1968. H. zea constituted over half the catch up to 1047 ft. It is inferred that the moths were taking part in a mass migration in the warm winds from Florida and across Georgia.

160 COCKERELL, T.D.A. (1914). The cotton-worm moth in Colorado. Journal of Economic Entomology, **7**: 405. [En.]

Migratory flight indicated by a large influx of H. zea to electric lights in Boulder on September 21, 1914. Moths thought to have originated at least 500 miles away.

161 COCKERELL, T.D.A. (1919). On the absence of insect pests in certain localities and on certain plants. Journal of Economic Entomology, **12**: 345-347. [En.]

States that H. zea migrates to Boulder, Colorado, from the south in the late summer.

162 COMMONWEALTH INSTITUTE OF ENTOMOLOGY. (1951-). Distribution maps of pests. London, CIE. [Loose leaf binder; replacement and new maps issued.] [En.]

Map 238: H. virescens, map 239: H. zea.

163 FELT, E.P. (1925). The dissemination of insects by air currents. Journal of Economic Entomology, **18**: 152-158. [En, en.]

Discusses reasons, including drifting on prevailing southerly or southwesterly winds, for H. zea appearing in southern Canada when overwintering probably does not occur north of southern Pennsylvania.

164 FELT, E.P. (1928). Dispersal of insects by air currents. New York State Museum Bulletin, **274**: 59-129. [En.]

Suggests northward movement of H. zea undertaken by a few individuals which oviposit and produce new generations en route. The short life cycle leads to a quick serious infestation in northern United States and southern Canada, further north than their overwintering limit of southern Pennsylvania.

165 GENTRY, C.R., DICKERSON, JR., W.A. & STANLEY, J.M. (1971): Populations and mating of adult tobacco budworms and corn earworms in northwest Florida indicated by traps. Journal of Economic Entomology, 64 (1): 335-338 [En.]

Light trap records showing seasonal peaks of H. virescens and H. zea populations which occurred several times each year, always after tobacco harvest and stalk destruction.

166 GLICK, P.A. (1939). The distribution of insects, spiders, and mites in the air. United States Department of Agriculture Technical bulletin, no. 673: 150 pp. [En, en.]

Record of one H. zea captured at 500 feet at night.

167 GLICK, P.A. (1965). Review of collections of Lepidoptera by airplane. Journal of the Lepidopterists' Society, 19 (3): 129-137. [En, en.]

One H. zea caught at 500 feet above Louisiana.

168 GLICK, P.A. & GRAHAM, H.M. (1965). Seasonal light-trap collections of lepidopterous cotton insects in South Texas. Journal of Economic Entomology, 58 (5): 880-882. [En, en.]

Studies of H. virescens and H. zea populations in the Rio Grande valley, Texas, were carried out from 1959 to 1963. H. virescens reached peak abundance in August during most years while H. zea peaked a month earlier.

169 HAILE, D.G., SNOW, J.W. & YOUNG, J.R. (1975). Movement by adult Heliothis released on St. Croix to other islands. Environmental Entomology, 4 (2): 225-226. [En, en.]

Marked and sterilized adult H. virescens and H. zea were released on St. Croix in 1972. Virgin female traps were operated on the islands of St. Thomas and Vieques, 38 miles NNW and 42 miles NW of St. Croix respectively. On Vieques, 18 out of 260 H. virescens and 2 of 5 H. zea taken were marked, and on St. Thomas 5 of 223 H. virescens were also marked. On Vieques 4 marked H. virescens eggs were found. Thus, St. Croix is not as isolated from insect movements as was expected.

170 HARDWICK, D.F. (1965). The corn earworm complex. Memoirs of the Entomological Society of Canada, 40: 247 pp. [En.]

Review of evidence for Heliothis migration, including seasonal northerly movements of H. zea. Suggests that migration may have evolved due to population pressures although some work suggests a genetic rather than environmental influence. Large key to literature concerning Helicoverpa complex.

171 HARTSTACK, A.W., LOPEZ, J.D., MULLER, R.A., STERLING, W.L., KING, E.G., WITZ, J.A. & EVERSULL, A.C. (1982). Evidence of long range migration of Heliothis zea (Boddie) into Texas and Arkansas. The Southwestern Entomologist, 7: (4): 188-201. [En, en.]

Evidence is presented, using pheromone trap data, for mass migration of H. zea from Mexico or southern Texas to College Station, Texas and Portland, Arkansas between 26 March and 8 April 1981. During the same period, no evidence was obtained for a comparable migration of H. virescens. Atmospheric opportunities for the transport of H. zea prevailed a large percentage of the time during the early season.

172 HENDRICKS, D.E., GRAHAM, H.M. & RAULSTON, J.R. (1973). Dispersal of sterile tobacco budworms from release points in northeastern Mexico and southern Texas. Environmental Entomology, 2 (6): 1085-1088. [En, en.]

Marked and sterilized adult H. virescens were released from two sites; 20 miles east of San Fernando (90 miles south of Brownsville, Texas) from Feb. 16 to June 16, 1971, and 18 miles north northwest of Brownsville, from June 18 to Nov. 2. Virgin female traps set at known distances at cardinal compass directions, collected marked moths. In Mexico male moths dispersed 10 miles north in 24 hours whereas in Texas they moved up to 70 miles in 4 to 5 days. Wind direction did not appear to have a consistent effect upon adult dispersal and the presence of major areas of cultivated crop caused only high densities of local not marked moths.

173 HENNEBERRY, T. (Discussion chairman) (1979). II Pest management. pp. 199-203 In: Vaughn, C.R., Wolf, W. & Klassen, W. (eds.) Radar, insect population ecology and pest management. Wallops Island, Virginia, National Aeronautics and Space Administration (NASA Conference Publication, 2070). (Proceedings of a workshop jointly sponsored by the National Aeronautics and Space Administration and U.S. Department of Agriculture, Science and Education Administration, held at Wallops Flight Center, May 2-4, 1978.) [En.]

H. zea and H. virescens overwinter as diapausing pupae throughout southern U.S. and as continuous generations in southern Florida and Texas, and certain western states. Active spring and summer generations migrate to agronomic crops.

174 KENNEDY, J.S. & WAY, M.J. (1979). Summing up the conference. pp 446-456. In: Rabb, R.L. & Kennedy, G.G. (eds.) Movement of highly mobile insects: concepts and methodology in research. Raleigh, N.C., North Carolina State University. (Proceedings of a Conference, "Movement of Selected Species of Lepidoptera in the Southeastern United States", Raleigh, North Carolina, April 9-11, 1979.) [En.]

Summarizes papers by: Phillips, J.R. (1979), Raulston, J.R. (1979) and Sparks, A.N. (1979).

175 KNIPLING, E.F. (1979). Strategic and tactical use of movement information in pest management. pp. 41-57. In: Vaughn, C.R., Wolf, W. & Klassen, W. (eds.) Radar, insect population ecology and pest management. Wallops Island, Virginia, National Aeronautics and Space Administration (NASA Conference Publication, 2070). (Proceedings of a workshop jointly sponsored by the National Aeronautics and Space Administration and U.S. Department of Agriculture, Science and Education Administration, held at Wallops Flight Center, May 2-4, 1978.) [En.]

The significance of northerly migrations of H. zea in the USA during the warmer months is discussed, and justification given for the management of Heliothis on a regional or national scale because of its migratory behaviour.

176 KOGAN, J., SELL, D.K., STINNER, R.E., BRADLEY, J.R. & KOGAN, M. (1978). The literature of arthropods associated with soybean, V A bibliography of Heliothis zea (Boddie) and H. virescens (F.) (Lepidoptera: Noctuidae). Urbana, Illinois, University of Illinois at Urbana - Champaign, College of Agriculture, International Soybean Program (INTSOY Series No. 17). 242 pp [En.]

5178 references to Heliothis spp. including behaviour, population studies, host records and distribution.

177 LASTER, M.L. & SMITH, J.W. (1982). Studies to estimate the density of the Heliothis virescens overwintered population and to determine the dispersal and response to pheromone traps of the natural and released insects. pp 195-197 in: Brown, J.M. (ed.) Proceedings, Beltwide Cotton Production Research Conferences 1982, January 3-7 1982, Las Vegas, Nevada. Memphis, National Cotton Council of America, vi + 302 pp. [En.]

H. virescens moths, marked as larvae and carrying the male sterility trait, were released in a 20 mile square grid in the central Delta of Mississippi centred around Washington County. 136 pheromone cone traps were used to recapture moths until none was left in the population. Of released moths, 1.8% were recaptured, most were randomly distributed within a 1.75 mile radius but some moths were taken up to 20 miles from the release site.

178 LINGREN, P.D. & WOLF, W.W. (1982). Nocturnal activity of the tobacco budworm and other insects. pp 211-228 in: Hatfield, J.L. & Thomason, I.J. (eds.) Biometeorology in integrated pest management. London, Academic Press. (Proceedings of a Conference on Biometeorology and Integrated Pest Management held at the University of California, Davis, July 15-17, 1980.) 491 pp. [En.]

Early evening take-off of H. virescens observed in Arizona with most moths in the air after the first hour after sunset. Most activity within 16 m of the ground but seen up to 50 m from ground level. Plumes of moths seen taking off together on radar.

179 LOPEZ, JR., J.D., HARTSTACK, JR., A.W., WITZ, J.A. & HOLLINGSWORTH, J.P. (1979). Recovery in blacklight traps of marked bollworms released in a multiple cropped area. The Southwestern Entomologist, 4 (1): 40-52. [En, en, es.]

Dispersal experiments carried out in Texas with marked H. zea showed that 7.8% of males and 6.7% of females were recaptured by blacklight traps in a 20 hectare corn/sorghum/cotton field. Eighty percent of these were taken within two nights of release showing that the moths either dispersed away within that period or did not survive.

180 MANGAT, B.S. (1976). Moth activity of Heliothis zea (Boddie) in Wisconsin (Lepidoptera: Noctuidae). Journal of the Tennessee Academy of Science, 51 (3): 112-113. [En, en.]

Blacklight trap batches of H. zea at Arlington, Wisconsin, 1961-64, showed moths to appear in the last week of August, or first week of September. Two adults were taken in July 1964. This uniform flight periodicity suggests that the moths emerge from a local population but the possibility of migration from the south is under investigation.

181 PHILLIPS, J.R. (1979). Migration of the bollworm, Heliothis zea (Boddie). pp 409-411 In: Rabb, R.L. & Kennedy, G.G., (eds.), Movement of highly mobile insects: concepts and methodology in research. Raleigh, N.C, North Carolina State University. (Proceedings of a Conference, "Movement of Selected Species of Lepidoptera in the Southeastern United States", Raleigh, North Carolina, April 9-11, 1979) [En.]

Short review of some evidence for Heliothis spp. migration. Since 1972 it has not been possible to detect any indication of large immigrating flights into Arkansas. If emigration and immigration has occurred, it has done so without any net effect on seasonal population dynamics.

182 PHILLIPS, J.R., LINCOLN, C. & HOLLOWAY, R.L. (1968). Movements of adult bollworms in Arkansas. Arkansas Farm Research, 17 (4): 2. [En.]

Migrations of H. zea suspected to occur into south Arkansas up to July. Shown by the light colouration of some moths' wings from March to July, an indication of emergence from diapause, whilst those from August to September were all dark winged. A light trap study and larval count of 20 square miles of Jefferson Community, Desha County, showed there to be an insufficient population during May and June to account for the July outbreaks.

183 PROSHOLD, F.I. & SMITH, J.W. (1982). The potential for hybrid sterility in Heliothis virescens management. pp 182-184 In: Brown, J.M. (ed.), Proceedings, Beltwide Cotton Production Research Conferences 1982, January 3-7 1982, Las Vegas, Nevada. Memphis, National Cotton Council of America. vi + 302 pp. [En.]

Sterile backcross male progeny of female crosses between H. virescens and H. subflexa were released on St. Croix in recapture experiments. Nearly 60% of males recaptured were trapped within half a mile of the release site and another 24% within the next half mile. No male moths were recaptured beyond ten miles of the release site.

184 QUAINANCE, A.L. & BRUES, C.T. (1905). The cotton bollworm. United States Department of Agriculture, Bureau of Entomology Bulletin, No 50: 155 pp. Washington, Government Printing Office. [En.]

Description of night habits indicating movement of moths over several acres in one hour. Also notes that moth activity begins earlier in the evening when food is scarce.

185 RAULSTON, J.R. (1979). Heliothis virescens migration. pp 412-419 In: Rabb, R.L. & Kennedy, G.G., (eds.), Movement of highly mobile insects: concepts and methodology in research. Raleigh, N.C., North Carolina State University. (Proceedings of a Conference, "Movement of Selected Species of Lepidoptera in the Southeastern United States", Raleigh, North Carolina, April 9-11, 1979.) [En.]

States that no major efforts have been made to actually follow native Heliothis moths over a migratory path from one geographical location to another. Reviews studies which indicate mobility. Presents new data from Lower Rio Grande Valley, Colorado, indicating strong possibility of early season movement into the area.

186 SANDERSON, E.D. (1908). The influence of minimum temperatures in limiting the northern distribution of insects. Journal of Economic Entomology, **1** (4): 245-262. [En.]

Records H. zea in northern United States and Ontario. Discusses effect of minimum temperatures upon limit of distribution.

187 SELMAN, C.L. & BARTON, H.E. (1972). Seasonal trends in catches of moths of twelve harmful species in blacklight traps in northeast Arkansas. Journal of Economic Entomology, **65** (4): 1018-1021. [En, en.]

Records of trap catches April-November 1970 in Craighead county show peaks of H. zea activity in early and late September.

188 SNOW, J.W., CANTELLO, W.W. & BOWMAN, M.C. (1969). Distribution of the corn earworm on St. Croix, U.S. Virgin Islands, and its relation to suppression programs. Journal of Economic Entomology, **62** (3): 606-611. [En, en.]

Investigations show that distribution of adult H. zea is neither random nor determined by either wind or terrain. Labeled moths originating from a central source dispersed non-randomly up to ten miles (as far as land was available on the island) from that point. Distribution kept mainly to lower elevations and areas of 35-45 inches of rain, high concentrations occurring around host plant fields.

189 SNOW, J.W. & COPELAND, W.W. (1971). Distribution and abundance of the corn earworm in the United States. Cooperative Economic Insect Report, **21**(2): 71-76. [En, en.]

Review of 19 years (1951-1969) observations on Heliothis overwintering and first appearances in relation to winter freezing. Concludes that local overwintering may be reason for moth populations rather than migration from the south.

190 SNOW, J.W., SPARKS, A.N. & LEWIS, W.J. (1972). Seasonal capture of corn earworm adults in light traps near Tifton, Georgia, compared with captures in traps baited with virgin females. Journal of the Georgia Entomological Society, **7** (2): 85-89. [En.]

Monthly collection data showing distribution of activity of H. zea for year 1967-68, with maximum abundance in July/August. Virgin female traps were more efficient in capturing males in the spring and early summer but less efficient in the higher natural population of mid-summer.

191 SPARKS, A.N. (1972). Heliothis migration. Southern Cooperative Series Bulletin, no. 169: 15-17. [En.]

States that little factual data are available on dispersal. Reviews various published and unpublished works on likely Heliothis migration including the distance and extent of dispersal and the altitudes of catches.

192 SPARKS, A.N. (1978). Migration of Heliothis spp. and other noctuids. Folia Entomologica Mexicana, **39-40**: 131-132. [En, summary only.]

Brief summary of results obtained in dispersal studies. H. zea and H. virescens disperse into suitable oviposition sites over an 84-square mile area upon emergence from a spent host and are capable of dispersing from a central location up to 16 miles in opposite directions in one night, up to 42 miles between Caribbean Islands, at altitudes of above 1000 feet in controlled flight, and up to 100 miles nonstop over water.

193 SPARKS, A.N. (1979). An Introduction to the status, current knowledge, and research on movement of selected Lepidoptera in south eastern United States. pp. 382-385 in: Rabb, R.L. & Kennedy, G.G. (eds.), Movement of highly mobile insects: concepts and methodology in research. Raleigh, N.C., North Carolina State University. (Proceedings of a Conference, "Movement of Selected Species of Lepidoptera in the Southeastern United States", Raleigh, North Carolina, April 9-11, 1979.) [En.]

Review of data concerning movement and migration of Heliothis spp. Concludes that H. zea can disperse over an 84-square mile area; Heliothis spp. travelled up to 42 miles over water, and moths can be caught throughout the growing season up to 1000 feet above ground.

194 SPARKS, A.N., JACKSON, R.D. & ALLEN, C.L. (1975). Corn earworms: capture of adults in light traps on unmanned oil platforms in the Gulf of Mexico. Journal of Economic Entomology, **68** (4): 431-432. [En, en.]

H. zea were taken at blacklight traps running from sunset to sunrise between 13 Sept and 21 Oct 1973. Traps on oil platforms 20, 46, 66 and 100 miles due south of Jeanerette, Louisiana, took 27, 16, 8 and 3 adult moths respectively. Majority of moths probably travelled on a southbound cool front.

195 SPECHT, H.B. (1979). Light trapping corn earworm and fall armyworm. Canada Agriculture, **24** (4): 23-24. [En, fr.]

Light trapping records of H. zea at ten traps in Nova Scotia from August 3rd - October 30 1978.

196 STADELBACHER, E.A. & PFRIMMER, T.R. (1972). Winter survival of the bollworm at Stoneville, Mississippi. Journal of Economic Entomology, **65** (4): 1030-1034. [En, en.]

Light trap collections indicate migration of H. zea into the Mississippi Delta area before local moths emerge.

197 STEWART, P.A., GENTRY, C.R., KNOTT, C.M. & LAM, J.J. (1968). Seasonal trends in catches of moths of the tobacco hornworm, tomato hornworm and corn earworm in traps equipped with blacklight lamps in North Carolina. Journal of Economic Entomology, 61 (1): 43-46. [En, en.]

Weekly trap catches of H. zea showing population fluctuations between May 16 and October 17, 1963-66. An abrupt increase resulted in the season's peak in mid-August.

198 STEWART, P.A. & LAM, J.J. (1968). Catch of insects at different heights in traps equipped with blacklight lamps. Journal of Economic Entomology, 61 (5): 1227-1230. [En, en.]

Records of H. zea at heights from 0 to 99 feet in North Carolina.

199 STINNER, R.E., WILSON, K., BARFIELD, C., REGNIERE, J., RIORDAN, A. & DAVIS, J. (1982). Insect movement in the atmosphere. pp 193-209 In: Hatfield, J.L. & Thomason, I.J., (eds.) Biometeorology in integrated pest management. London, Academic Press. (Proceedings of a Conference on Biometeorology and Integrated Pest Management held at the University of California, Davis, July 15-17, 1980.) 491 pp. [En.]

H. zea adults are highly mobile and move from crop to crop, depending upon host preference and plant maturity, and also over longer distances as far north as southern Canada.

200 TIPPINS, H.H & BESHEAR, R. (1975). Records of Heliothis spp. collections in a light trap operated continuously between 1965 and 1974. Georgia Agricultural Experiment Station Research Report, no. 212: 18 pp. [En.]

Light trap records presented for H. virescens and H. zea in Georgia. Fifty-seven percent of H. zea were collected in August. It is suggested that many of these moths may have been migrants.

201 U.S. DEPARTMENT OF AGRICULTURE, ANIMAL AND PLANT HEALTH INSPECTION SERVICE, PLANT PROTECTION AND QUARANTINE PROGRAMS. (1952-81). Plant Pest News v1. (1-6), 1981 only, continued from: Cooperative Plant Pest Report v1, 1976 - v5, 1980, continued from: Cooperative Economic Insect Pest Report v1, 1951 - v25, 1975. [En.]

Frequent reports of Heliothis spp. status in United States, including sightings, trap catches and numbers, in all volumes.

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