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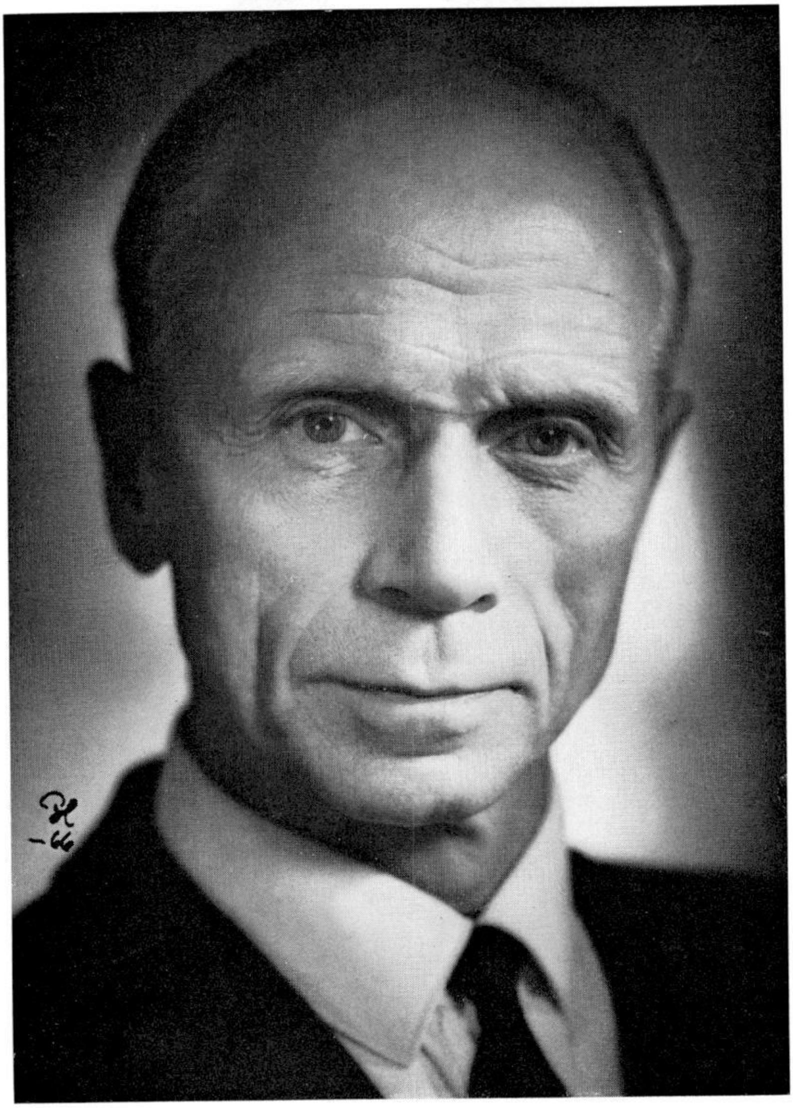

FAIR DEALING AND SOUND JUDGEMENT

VEIKKO KANERVO 70 YEARS OLD

The best years for a scientist, the years when he produces his most creative and original work, usually occur during what might well be called late youth, the period before he actually reaches middle age. For Veikko Kanervo the greater part of this period was not spent doing research. In 1939, at the age of 33, he left for the Finnish "Winter War" and when he returned at the end of the "Continuation War", 1944, he was 38.

Publication of doctoral standard in 1936

However, in the short time before the war years, Kanervo had already made a thorough study of practical plant protection, gained considerable scientific recognition through his publications and collected comprehensive material on the solving of various pest problems. The most important of his publications from that period was "The Diamond Back Moth (*Plutella maculipennis* Curt.) as a pest of cruciferous plants in Finland", which in its commentary and approach was among the foremost papers of its time. It clearly surpassed the standards required for a doctoral thesis, although it was not published as such.

In 1936, the year Kanervo brought out his study on the Diamond Back Moth, his superior, Yrjö Hukkinen, at that time director of the Department of Pest Investigation at the Agricultural Research Centre, received his doctor's degree. Hukkinen was well known as a specialist in thrips research. The professor of plant pathology at Helsinki University, J. I. Liro, is reported to have said something to the effect that Kanervo could just as well have got his doctorate with his *Plutella maculipennis* as Hukkinen with his *Chirothrips hamatus*.

Thesis immediately after the war

Before the war years Veikko Kanervo had time to collect most of the material for his thesis. In 1946 he brought out the first thesis on biological pest control ever published in Finland: "Studies on the natural enemies of *Melasoma aenea* L. (Col. Chrysomelidae)". At the time no organisms sufficiently effective to combat the mustard beetle (*Phaedon cochleariae* L.) had been found among its natural enemies. Kanervo attempted to remedy this in a round-about-way. The ultimate objective of his doctoral work was to discover among the predators and parasites of *Melasoma aenea* those organisms which could be used to combat the mustard beetle too, and possibly even Colorado potato beetle.

The year Kanervo's thesis was published, 1946, also saw the death of Professor Yrjö Hukkinen, who for 18 consecutive years had led the Department. From his good friend Hukkinen, Kanervo had learnt to appreciate basic research, and at the same time to recognize that the researcher's first duty lays in helping farmers and gardeners with their pest problems.

Directorship, but no time to prepare

Soon after Yrjö Hukkinen's death, Veikko Kanervo was appointed professor and head of the Department of Pest Investigation. The official appointment, made by the President of the Republic, was dated June 6, 1947 and Kanervo was required to take up his duties at that date. Thus recently returned from the war and having just aequired his doctoral he, somewhat abruptly, found himself directing agricultural pest investigation and acting as the leading expert on problems of pest control in farmland, gardens, dwellings and storehouses.

At 41 years of age the new head of the Pest Investigation Department landed right in the middle of a revolution that was taking place in the development of plant protection. DDT and BHC had already appeared on the market and organic phosphorus products of a completely new type were soon the subjects of research. Growers were very interested in the new "miracle products", which, it was said, would kill pests that up till then had been thought invulnerable. The new pesticides were naturally also of interest to the trade, which wanted to keep abreast of foreign development. Thus new products appeared on the market continuously.

New pesticides to be approved before marketing

Kanervo saw that under these circumstances it would be necessary to regulate chemical pest control. Together with Professor E. A. Jamalainen, head of the Plant Pathology Department, he published Finland's first list of pesticides, "Plant Protectants in 1948". This listed the products that the Pest Investigation and Plant Pathology departments could recommend on the basis of their own experiments and experience. Already at that time Kanervo and Jamalainen were aiming at legislative control, the creation of a permit procedure and the publication of an official pesticides catalogue, as means of supervision and as guidelines for the trade and growers.

Proposals for legislation and statutes were quickly drawn up by the Plant Protection Committee. These were to a great extent, based on the Danish pesticide system of regulation at that time. The Plant Protection Chemicals Act came into force at the beginning of 1952. It stipulated that the Plant Pathology and Pest Investigation Departments of the

Agricultural Research Centre, should constitute a Pesticide Regulation Unit responsible for enforcing the act. At that time, comparable statutes had been introduced in only a few countries, not yet, e.g., in Finland's neighbouring countries, Sweden and Norway.

During his time as head Kanervo concentrated his resources on determining the efficiency and usability of the various pesticides, so that the new products would be at the disposal of farmers as quickly as possible. For well over ten years the researchers at the Department of Pest Investigation spent most of their working hours studying chemical control methods, in fact half the researchers spent years doing nothing but pesticide tests.

Chemical control not the ultimate solution

It was typical of Kanervo's far-sightedness that he should preserve a critical attitude towards the potentials of chemical pest control. He never thought that chemicals would exterminate pests completely or that an ultimate solution to the pest problem could be found by using chemicals.

During the early 1950s he initiated investigation into the resistance of the house fly to DDT and other chlorinated hydrocarbons. At the end of the decade, Kanervo started a comprehensive programme of research into the effect of pesticides on the entire fauna of orchards. The chief aim of this research was to clarify how pesticides, used according to the instructions, affect the natural enemies of pests and economically unimportant insects and mites.

Damage to oats spread by the leafhopper

Perhaps the most important scientific achievement that Kanervo accomplished during his term of directorship was to solve the problem of damage to oats. This damage had caused great yield losses in Ostrobothnia and other parts of Finland during the 1950s. With the support of an unusually substantial financial grant from the U.S.A. a thoroughgoing investigation was made at a field laboratory situated in Laihia under Kanervo's leadership into the distribution symptoms and causes of damage. Pekka Nuorteva, on the basis of his own investigations, had advanced the theory that the damage was caused by toxin in the spittle of *Javesella pellucida*. On the other hand, Kanervo with his team of workers came to the conclusion that the damage must be caused by a virus spread by *J. pellucida*. Tests carried out independently by Katri Ikäheimo (Bremer), researcher at the Plant Pathology Department, confirmed this assertion. The oat sterile dwarf virus was at that time known only in Czechoslovakia.

The findings of Kanervo's research team were considered of major importance in the U.S.A. A member of the team, Mikko Raatikainen, aroused widespread international attention with his doctorial thesis, "Bionomics, enemies and population dynamics of *Javesella pellucida* (F.) (*Hom.*, *Delphacidae*)". This was the Pest Investigation Department's second doctorial thesis in the field of biological pest control.

Kanervo no autocrat — chores agreed on

As head of the Department of Pest Investigation Veikko Kanervo did not usually delegate work to his researchers. This meant of course that he had less time for his own scientific work, but for the researchers the opportunities for delibrate and consistent studies were greatly increased. It is true that each researcher was responsible for at least one of routine task, e.g. care of the library, secretarying departmental meetings, arranging the insect collections, supervising use of the car, procuring instruments and taking care of them. Allocation of these tasks was however, agreed on mutually at a general meeting because the director did not wish to decide such matters, or indeed, almost any, himself.

Kanervo worked with unremitting zeal to improve his department's possibilities for carrying out its activities. He constantly made its needs known by every means in his power, and suggested ways in which things could be improved. After a time this work began to yield results. The number of researchers and technical assistants was increased, thus enabling the Department to develop a more comprehensive research programme of greater benefit to farmers and gardeners.

Completion of the new laboratory building

In 1963 Kanervo achieved what was, perhaps, the most important of his goals, one for which he had been striving for well over ten years. This was the completion of the research centre's new laboratory building, providing adequate work space for the Pest Investigation Department, which ever since its establishment in 1898 had been working under unsatisfactory and cramped conditions.

Kanervo's activities have not, however been confined within the walls of his own department. He has been an active participant in organizations and institutions in his own field, e.g. as chairman of the Plant Protection Society of Finland and of the Scientific Agricultural Society of Finland, as vice chairman of the Entomolgical Society of Finland and of the National Research Council for Agriculture and Forestry, as well as a member of the Board of the European and Mediterranean Plant Protection Organization (EPPO) and of the Plant Protection Section of the Scandinavian Association of Agricultural Scientists.

I join the other contributors to this special birthday issue in offering you, Veikko, our heartfelt good wishes for your 70th birthday on the 14th July, 1976. It is gratifying to continue on the foundations which you laid so well.

Martti Markkula

TASAPUOLISUUTTA JA HARKINTAA

VEIKKO KANERVO 70-VUOTIAS

Tiedemiesten parhaat, uutta tietoa tuottavat toiminnallisuuden vuodet ajoittuvat yleensä vaiheeseen, jota voisi sanoa vaikkapa myöhäisnuoruudeksi, aikaan ennen varsinaista keski-ikää. Olennaisimman osan tuosta ajasta Veikko Kanervo oli muussa kuin tutkijan työssä. Hän lähti Talvisotaan 33-vuotiaana ja palasi Jatkosodasta 38-vuotiaana.

Väitöskirjaksi sopiva julkaisu vuonna 1936

Kuitenkin jo ennen sotavuosia Kanervo oli lyhyessä ajassa perusteellisesti paneutunut käytännön kasvinsuojeluun, hankkinut julkaisuillaan huomattavan tieteellisen pätevyyden ja kerännyt monipuolisia aineistoja erilaisten tuholaisongelmien ratkaisemiseksi. Silloisista julkaisuista oli ansiokkain »Kaalikoi (*Plutella maculipennis* Curt.) ristikukkaiskasvien tuholaisena Suomessa», joka rakenteeltaan ja ongelmanasettelultaan kuului aikansa eturiviin. Se ylitti selvästi väitöskirjalle asetettavat vaatimukset, vaikkakaan sitä ei julkaistu väitöskirjana.

Samana vuonna 1936, jolloin Kanervo julkaisi kaalikoi-tutkimuksensa, väitteli tohtoriksi hänen esimiehensä, Maatalouskoelaitoksen tuhoeläinosaston silloinen johtaja Yrjö Hukkinen. Hukkinen oli erityisesti ripsiäistutkijana laajalti tunnettu. Helsingin yliopiston kasvipatologian professorin J. I. Liron kerrotaan sanoneen jotenkin tähän tapaan: Aivan yhtä hyvin olisi Kanervo voinut väitellä kaalikoillaan kuin Hukkinen puntarpääripsiäisellä.

Väitöskirja heti sodan jälkeen

Ennen sotavuosia Veikko Kanervo ehti koota pääosan tulevan väitöskirjansa aineistosta. Vuonna 1946 hän julkaisi maamme ensimmäisen biologisen torjunnan alaan kuuluvan väitöskirjan »Tutkimuksia lepän lehtikuoriaisen, *Melasoma aenea* L. (*Col.*, *Chrysomelidae*) luontaisista vihollisista». Kun sinappikuoriaisen vihollisista ei aikanaan löytynyt riittävän tehokkaita torjuntaeliöitä, Kanervo pyrki päämääräänsä mutkan kautta. Väitöskirjatyön etäisenä tavoitteena oli löytää lepän lehtikuoriaisen vihollisten joukosta sellaisia petoja ja loisia, jotka soveltuisivat sinappikuoriaisen ja ehkä myös koloradonkuoriaisen torjuntaan.

Samana vuonna 1946, jolloin Kanervon väitöskirja ilmestyi, kuoli osaston johtajana 18 vuotta yhtäjaksoisesti toiminut professori Yrjö

Hukkinen lyhyen sairauden jälkeen. Hyvältä ystävältään Hukkiselta Kanervo oli oppinut arvostamaan biologista perustutkimusta, mutta kuitenkin pitämään tuhoeläintutkijan ensisijaisena tehtävänä maanviljelijöiden ja puutarhureiden auttamista heidän tuholaisongelmissaan.

Johtajaksi ilman valmistumisaikaa

Pian Yrjö Hukkisen kuoleman jälkeen Veikko Kanervo nimitettiin tuhoeläinosaston johtajaksi ja professoriksi. Tasavallan Presidentin antama valtakirja oli päivätty 7. 6. 1946 ja nimitetyn tuli astua tehtäväänsä samana päivänä. Näin hän joutui vasta äskettäin sodasta palanneena ja tohtoriksi väitelleenä, jokseenkin äkikseltään johtamaan maatalouden tuhoeläintutkimusta ja samalla toimimaan pääasiantuntijana pellon, puutarhan, asuntojen ja varastojen tuholaisongelmissa.

Tuhoeläinosaston uusi, 41 vuotias johtaja joutui keskelle käynnissä olevaa kemiallisen torjunnan vallankumousta. DDT ja BHC olivat jo tulleet kauppaan ja kokonaan uudentyyppiset, orgaaniset fosforivalmisteet olivat pian tutkimusten kohteena. Viljelijät olivat varsin kiinnostuneita uusista »ihmeaineista», joiden piti tappaa siihen asti voittamattomina pidetyt tuholaiset. Uutuudet kiinnostivat luonnollisesti myös kauppaa, joka halusi pysyä ulkomaisen kehityksen tasalla. Näin ilmaantui markkinoille uusia tuotteita jatkuvasti.

Uudet torjunta-aineet tarkastettava ennen myyntiä

Tässä tilanteessa Kanervo näki, että kemiallisen torjunnan kehitystä oli ryhdyttävä ohjaamaan. Yhdessä kasvitautiosaston johtajan, professori E. A. Jamalaisen kanssa hän julkaisi maamme ensimmäisen kasvinsuojeluaineluettelon »Kasvinsuojeluaineet vuonna 1948». Siinä mainittiin erityismerkinnöin ne kauppavalmisteet, joita kasvinsuojeluosastot kokeittensa ja kokemuksensa perusteella suosittelivat käytettäviksi. Jo tällöin Kanervolla ja Jamalaisella oli tavoitteena lakiin perustuvan tarkastuksen järjestäminen, lupamenettelyn luominen ja virallisen kasvinsuojeluaineluettelon julkaiseminen valvonnan välineeksi sekä kauppiaiden ja viljelijöiden ohjaamiseksi.

Kasvinsuojelukomiteassa valmistui nopeasti ehdotus laiksi ja asetukseksi. Ehdotus perustui paljolti Tanskan silloiseen tarkastusjärjestelmään. Laki kasvinsuojeluaineista tuli voimaan vuoden 1952 alusta ja se määräsi maatalouskoelaitoksen kasvitautiosaston ja tuhoeläinosaston kasvinsuojelulaitoksena vastaamaan lain toimeenpanosta. Vertaissäädöksiä oli tuolloin voimassa vain harvassa maassa, ei esimerkiksi naapurimaissamme, Ruotsissa ja Norjassa.

Kanervo kohdisti johtajakautensa toiminnan nimenomaan torjunta-aineiden tehokkuuden ja käyttökelpoisuuden selvittämiseen tavoitteenaan uusien, entistä parempien valmisteiden saattaminen mahdollisimman nopeasti viljelijöiden käyttöön. Pitkälti toistakymmenen vuoden ajan laitoksen tutkijoiden työaika kuluikin enimmältään kemiallisen torjunnan tutkimukseen. Niinpä puolet tutkijoista ei vuosiin tehnyt muuta kuin »myrkkytarkastusta».

Kemikaalit eivät tuo lopullista ratkaisua

Kanervon luontaiseen avarakatseisuuteen ja varovaisuuteen kuuluu, että hän säilytti kriittisen suhtautumisen kemiallisen torjunnan mahdollisuuksiin. Hän ei ajatellut, että tuholaiset pystyttäisiin kemikaaleilla hävittämään sukupuuttoon tai että kemikaalien käytöstä muutoinkaan löytyisi lopullinen ratkaisu tuholaisongelmiin.

Niinpä hänen aloitteestaan selvitettiin tuhoeläinosastolla 1950-luvun ensi vuosina huonekärpäsen resistenssiä DDT:tä ja muita kloorattuja hiilivetyjä vastaan. Vuosikymmenen lopussa Kanervo käynnisti laajan tutkimusohjelman »torjunta-aineiden vaikutuksista hedelmätarhojen kokonaisfaunaan». Tutkimuksen tarkoituksena oli nimenomaan selvittää, miten ohjeiden mukainen torjunta-aineiden käyttö vaikuttaa tuhoeläinten luontaisiin vihollisiin ja taloudellisesti merkityksettömiin hyönteisiin ja punkkeihin.

»Kauratuhoon» syynä kaskaan levittämä virus

Kanervon ehkä kaikkein merkittävin tieteellinen saavutus johtajakautenaan oli Pohjanmaalla ja osin muuallakin Suomessa 1950- ja 1960-luvun vaihteessa erittäin vahingollisena esiintyneen «kaurantuhon» selvittäminen. Yhdysvaltojen maatalousministeriön myöntämän poikkeuksellisen suuren apurahan turvin tutkittiin Kanervon johdolla viiden vuoden ajan erittäin perusteellisesti ja monipuolisesti kaurantuhon levinneisyyttä, oireita ja syitä. Tukikohtana oli Laihialle, entiseen Hulmin kasarmiin perustettu kenttälaboratorio. Pekka Nuorteva ehätti omien tutkimustensa perusteella esittämään tuhon aiheuttajaksi viljakaskaan syljessään erittämää toksiinia. Kanervo työryhmänsä kanssa oli sen sijaan tullut siihen tulokseen, että tuhon aiheuttajana täytyi olla viljakaskaan levittämä virus. Tämän päätelmän kasvitautiosaston tutkija Katri Ikäheimo (Bremer) osoitti omilla kokeillaan oikeaksi. Tuhon aiheuttaja, kauran tyviversovirus, oli silloin tunnettu ainoastaan Tsekkoslovakiasta.

Kanervon työryhmän tulokset arvioitiin Yhdysvalloissa varsin merkittäviksi. Laajan kansainvälisen huomion on saanut työryhmän jäsenen Mikko Raatikaisen väitöskirja »Bionomics, enemies and population dynamics of *Javesella pellucida* (F.) (*Hom.*, *Delphacidae*)», joka on toinen tuhoeläintutkimuslaitoksella valmistunut biologisen torjunnan alaan kuuluva väitöskirja.

Kanervo ei määrännyt — tehtävistä sovittiin

Tuhoeläintutkimuslaitoksen johtaja Veikko Kanervo ei yleensä jakanut tehtäviä tutkijoilleen. Tästä luonnollisesti johtui, ettei hänelle jäänyt paljonkaan aikaa omaan tieteelliseen työhön. Tutkijoilla sen sijaan oli huomattavasti suuremmat mahdollisuudet suunnitelmalliseen tutkimukseen. Tosin kunkin tutkijan hoidettavaksi osui ainakin yksi yhteinen tehtävä, esimerkiksi kirjaston hoito, laitoksen kokousten sihteerinä toimiminen, hyönteiskokoelmien järjestely, auton käytön valvonta, laitteiden hankinta ja huoltaminen. Näiden yhteisten tehtävien jakamisesta sovittiin tutkijoiden kokouksessa, sillä laitoksen johtaja ei tehtävien jaossa eikä juuri muissakaan asioissa halunnut määrätä.

Kanervo työskenteli väsymättä oman laitoksensa toimintamahdollisuuksien parantamiseksi. Hän jaksoi eri yhteyksissä asiallisesti ja kärsivällisesti selostaa maatalouden tuhoeläintutkimuksen tarpeita ja tehdä esityksiä tilanteen korjaamiseksi. Aikaa myöten ilmaantui työstä myös tuloksia. Uusia tutkijoiden ja avustajien toimia perustettiin ja näin voitiin laitoksen tutkimusohjelmaa monipuolistaa maanviljelijöiden ja puutarhureiden hyödyksi.

Uusi laboratoriorakennus valmistuu

Vuonna 1963 Kanervo pääsi tavoitteeseen, jonka saavuttamiseksi hän oli työskennellyt pitkälti toistakymmenen vuoden ajan. Tällöin valmistui tutkimuskeskuksen uusi laboratoriorakennus, josta tuhoeläintutkimuslaitos sai asianmukaiset työskentelytilat. Perustamisestaan, vuodesta 1898 lähtien laitos olikin toiminut varsin puutteellisissa ja ahtaissa oloissa.

Kanervon toiminta ei rajoittunut pelkästään laitoksen seinien sisäpuolelle. Hän toimi varsin ansiokkaasti oman alansa järjestöissä ja yhteisöissä, esimerkiksi puheenjohtajana Kasvinsuojeluseurassa ja Suomen Maataloustieteellisessä Seurassa, varapuheenjohtajana Suomen Hyönteistieteellisessä Seurassa ja Suomen Akatemian maatalous-metsätieteellisessä toimikunnassa sekä hallituksen jäsenenä Euroopan ja Välimeren maiden kasvinsuojelujärjestössä (EPPO) ja Pohjoismaiden maataloustutkijain yhdistyksen (NJF) kasvinsuojelujaostossa.

Maatalouseläintieteen dosenttina Kanervo luennoi agraariopiskelijoille tuhoeläinten torjunnasta parinkymmenen lukuvuoden aikana. Hän piti luentonsa jatkuvasti ajan tasalla ja kertoi kuulijoilleen nimenomaan uusimmista torjuntakeinoista.

Muiden tämän juhlajulkaisun kirjoittajien mukana esitän Sinulle Veikko sydämelliset onnentoivotukset täyttäessäsi seitsemän vuosikymmentä 14. heinäkuuta 1976. Sinun rakentamaltasi pohjalta on ollut laatuisaa jatkaa.

Martti Markkula

A SELECTION OF VEIKKO KANERVO'S PUBLICATIONS

This list includes 60 selected titles from Veikko Kanervo's works, which total, in all, several hundred papers. Selection was not based primarily on the scientific value of the papers, although the list contains more scientific than other papers. The aim has been to compile a short list which gives a good cross section of Kanervo's whole production.

1935 *Eumerus tuberculatus* Rond. (*Dipt., Syrphidae*) maalle uusi laji sipulin tuholaisena. Referat: *Eumerus tuberculatus* Rond. (*Dipt., Syrphidae*), ein für Finnland neuer Zwiebelschädling. Ann. Ent. Fenn. 1:101—106.

1936 Kaalikoi (*Plutella maculipennis Curt.*) ristikukkaiskasvien tuholaisena Suomessa. Summary: The diamond back moth (*Plutella maculipennis* Curt.) as a pest of cruciferous plants in Finland. Agric. Exp. Activ. Sta. Publ. 86: 1—86.

1937 Havaintoja Chrysomela variansin (*Col., Chrysomelidae*) biologiasta. Referat: Beobactungen zur Biologie von Chrysomela varians Schall. (*Col., Chrysomelidae*). Ann. Ent. Fenn. 3: 132—139.

1939 Übersicht über die Generationszahl einiger Chrysomeliden (*Col.*) in Finnland sowie einige andere allgemeine biologische Beobactungen. Ann. Ent. Fenn. 5: 140—164.

1939 Tutkimuksia hedelmäpuun punkista (*Paratetranychus pilosus* C. & F.) Summary: Studies of fruit tree red mite (*Paratetranychus pilosus* C. & F.). Agric. Exp. Activ. Sta. Publ. 99: 1—143. Authors: Listo, J., Listo, E.-M. & Kanervo, V.

1940 Beobachtungen und Versuche zur Ermittlung der Nahrung einiger Coccinelliden (*Col.*). Ann. Ent. Fenn. 6: 89—110.

1941 Zur Morphologie der präimaginalen Stadie von *Calvia 15-guttata* F. (*Col., Coccinellidae*). Ann. Ent. Fenn. 7: 52—60.

1942 Die Unterscheidungen der Larven und Puppen von *Eumerus tuberculatus* Rond. und *E. strigatus Fall.* (*Dipt., Syrphidae*). Ann. Ent. Fenn. 8: 227—233.

1944 Hyönteisten lisääntyväisyyteen vaikuttavista tekijöistä. Referat: Über die vermehrungsbeeinflussenden Faktoren bei den Insekten. Ann. Ent. Fenn. 10: 185—198.

1945 Hajahavaintoja eräiden hyönteislajien taudeista. 1—2. Summary: Sporadic observations concerning diseases in certain species of insects. 1 and 2. Ann. Ent. Fenn. 11: 218—227.

1946 Hajahavaintoja eräiden hyönteislajien taudeista. 3. Summary: Sporadic observations concerning diseases in certain species of insects. 3. Ann. Ent. Fenn. 12: 143—153.

1946 Tutkimuksia sinappikuoriaiskärpäsestä, *Meigenia mutabilis* Fall. Referat: Studien über *Meigenia mutabilis* Fall. Ann. Zool. Soc. Zool. Bot. Fenn. Vanamo 11, 5: 1—45. Authors: Kanervo, V. & Talvitie, Y. K. K.

1946 Tutkimuksia lepän lehtikuoriaisen, *Melasoma aenea* L. (*Col., Chrysomelidae*), luontaisista vihollisista. Referat: Studien über die natürlichen Feinde des Erlenblattkäfers. *Melasoma aenea* L. (*Col., Chrysomelidae*). Ann. Zool. Soc. Zool. Bot. Fenn. Vanamo 12, 3: 1—206.

1947 Über das Massenauftreten der Gammaeule, *Phytometra gamma* L. (*Lep., Noctuidae*) im Sommer 1946 in Finnland. Ann. Ent. Fenn. 13: 89—104.

1948 Effektivitätsundersökningar av bepudringsmedel. (Studies on the effeciency of powders.) Nord. Jordbr.forskn. 28: 566—567.

1948 Kasvinsuojeluaineet vuonna 1948. (Plant Protectants in 1948.) Publ. Hort. Assoc. Finl. 65: 1—15. Authors: Jamalainen, E. A. & Kanervo, V.

1948 On the epidemiology of Plutella maculipennis Curt. in Finland. Ann. Ent. Fenn. 14: 99—105.

1949 Tuhoeläinten torjunta-aineiden haitallisuudesta mehiläisille. (Harmfulness of insecticides to bees.) Mehiläistalous 4: 83—84.

1949 Tuhoeläinten torjunta-aineiden tutkimuksesta ja sen antamista tuloksista. (On the testing of the efficiency of insecticides and on the results of the tests.) Maatal. ja Koetoim. 4: 143—157.

1949 Orgaaniset fosfaattiyhdisteet, tuhoeläintorjunnan uusimpia aseita. (Organophosphorous compounds, the newest weapons in pest control.) Puutarha 52: 173—175.

1950 *Frankliniella tenuicornis* Uzel (*Thysanoptera*) als intrafloraler Schädling an Gerste. Eighth Intern. Congr. Ent. Proc. Stockholm p. 947—953.

1951 Riktlinjer för bekämpning av skadedjur på sädesväxter. (Rules of controlling cereal pests.) Nord. Jordbr.forskn. 31: 535—540

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ANNALES AGRICULTURAE FENNIAE, VOL. 15: 16—23 (1976)

Seria ANIMALIA NOCENTIA N. 75 — Sarja TUHOELÄIMET n:o 75

BIOLOGICAL PECULIARITIES OF HYLEMYA FLORALIS FALL. IN DENMARK

JØRGEN JØRGENSEN

JØRGENSEN, J. 1976. **Biological peculiarities of Hylemya floralis Fall. in Denmark.** Ann. Agric. Fenn. 15: 16—23. (R. Veter. Agric. Univ., Bülowsvej 13, DK 1870 København V, Denmark).

With a few exceptions, *Hylemya floralis* Fall. is found on sandy soil in Denmark only. Commonly, the species has one yearly generation, the hibernated pupae of which are starting to hatch at the end of July, reaching their maximum in August and finishing during September. Within a narrow geographical area in the northern part of Jutland, some deviations from the common pattern of development are discovered. The deviating type hatches much earlier, and in several cases two generations are normally developed. Besides these two types a third type is found. This type is considered a mixture of the two types mentioned above. The distribution of the deviating type is limited to the northern part of Jutland and to a few localities in the eastern part of the country.

Interbreeding the two types of univoltine and bivoltine populations has shown that reciprocal fertility occurs, and the life cycles of the offspring support the idea of the existence of an intermediary type. The reasons for the peculiarities could not be adequately explained.

Index words: *Hylemya floralis*, biology in Denmark.

Introduction

In the northwestern part of Europe *Hylemya floralis* Fall. is distributed from Finland in the East to Scotland in the West, and from the most northerly part of Norway in the North to the northern part of Germany and the Netherlands in the South. However, the main districts for the species are the middle and the northern part of this area, and in the Scandinavian countries (apart from Iceland) *H. floralis* Fall. plays a prominent part as a pest attacking several cruciferous crops.

The distribution and biology in Scandinavia is rather well known (LUNDBLAD 1933, WAGN 1953, JØRGENSEN 1957, RYGG 1962, VARIS 1967).

Within an area like Scandinavia it is obvious, that the biology diverges according to different climatic conditions, especially temperature and day length. In Denmark, however, some biological deviations which occur, within narrow geographical distances are more surprising and, consequently, interesting to investigate.

Preliminary results from such investigations have been given in earlier publications (JØRGENSEN 1957 and 1971). In this paper further details are discussed.

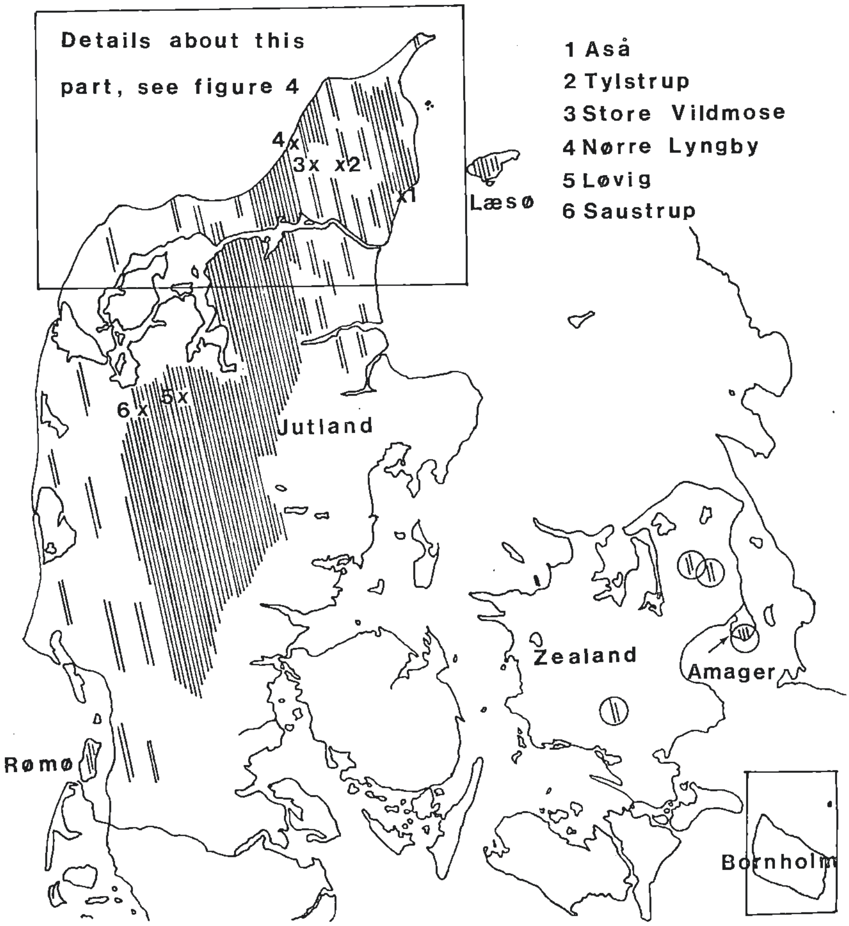

Fig. 1. Distribution of *Hylema floralis* Fall. in Denmark. Outside Jutland, the species has been found at Læsø, Rømø, Amager and Zealand. Some localities mentioned in the text are marked on the map.

Distribution and life cycle in Denmark

Development of *H. floralis* Fall. is virtually confined to the sandy soils in the northern and western parts of Jutland. Apart from this type of soil it can be found in a few places, but only in very limited areas, see figure 1.

Commonly, the species produces only one generation a year, the hibernated pupae of which start to hatch at the end of July reach their maximum in August and finish during September. Consequently, development of the pre-imaginal stages occurs in the autumn and the main damage to the host plants is done during the months of September and October, see figure 2. This pattern of development agrees with that described in other parts of the world, where the species is known.

The deviations occurring in Denmark were first observed in the northern part of Jutland about 1954—55, when larvae attacked swede turnips as early as the last half of June and during July. This early development was confirmed by catching adult flies as follows:

Number of males caught May 27—28, 1959:

Aså	60	(no 2 in figure 4)
Melholdt	200	(no 24 » » 4)
Gl. Hammelmose	210	(no 39 » » 4)
Nr. Økse	15	(no 5 » » 4)
Nr. Lyngby	10	(no 25 » » 4)

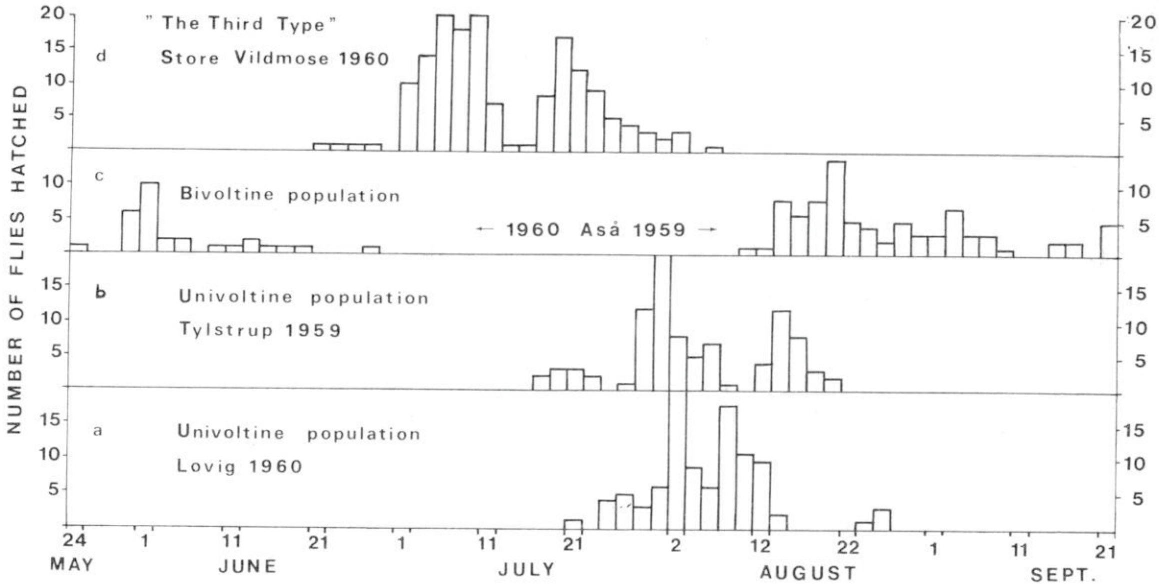

Fig. 2. Hatching periods for imagines of *Hylemya floralis* Fall. (Each column shows the number of flies hatched within 2 days). A. Pupae collected at Lövig, November 4, 1959. B. Pupae collected at Tylstrup, November 8, 1958. C. Larvae collected at Aså, July 8, 1959. Pupation during the rest of July 1959. 73 per cent hatched late in 1959, 27 per cent early 1960. D. Larvae collected at Store Vildmose, November 6, 1959. Pupation during November and primo December (see also Fig. 7). The situation of the localities can be seen in Fig. 1.

Methods

To determine the extent of the deviations in the populations a large number of eggs, larvae and pupae were collected during the years 1956—64 from different parts of the country. Further development was investigated at Statens plantepatologiske Forsøg, Lyngby, mainly by means of hatching control in insectaria, where about 38 000 flies originating from more than 100 localities were hatched, see figure 3.

To check the stability of the biological deviations, the flies were kept alive in some cases and breeding was carried out in small cages to obtain further generations of offspring. The adult flies were given a mixture of sugar solution to which small amounts of casein were added. The larvae developed in swede turnips grown in sandy soil, in big flower pots.

Figure 3. Hatching pots at the insectarium (For details of the method, see Jørgensen 1957).

Biological divergences occurring in the northern part of Jutland

The preliminary results showed that the biological divergences were especially concentrated to populations in the northern part of Jutland, within a rather restricted area and not throughout. The pattern of development can be divided into three types:

1. Univoltine populations
2. Bivoltine populations
3. Probably a mixture of 1 and 2 with a very long hatching period, see figure 2.

Figure 4 shows the situation of 61 localities in the northern part of Jutland where life cycles have been investigated. In some cases the larvae and pupae were collected at the same farms over a period of several years; in other cases the results cover more farms within the same parish.

It should be stressed, that in every case the results describe the biological conditions in a very small locality compared to the whole district.

As figure 4 shows, the univoltine type was found at 26 localities. This pattern corresponds in broad outline to that found in other parts of the country, apart from a slight tendency to develop earlier, see figure 2b.

The bivoltine type was found at 27 localities. The parttern for this type is characterized by the hibernated pupae hatching early, pre-imaginale stages developing in June and July, a large proportion of the summer-pupae hatching without diapause and a second generation developing in late summer and autumn. A pattern such as this has never before been described for *H. floralis* Fall. In the literature only one case (VARIS 1967) is reported, in which *H. floralis* from southern

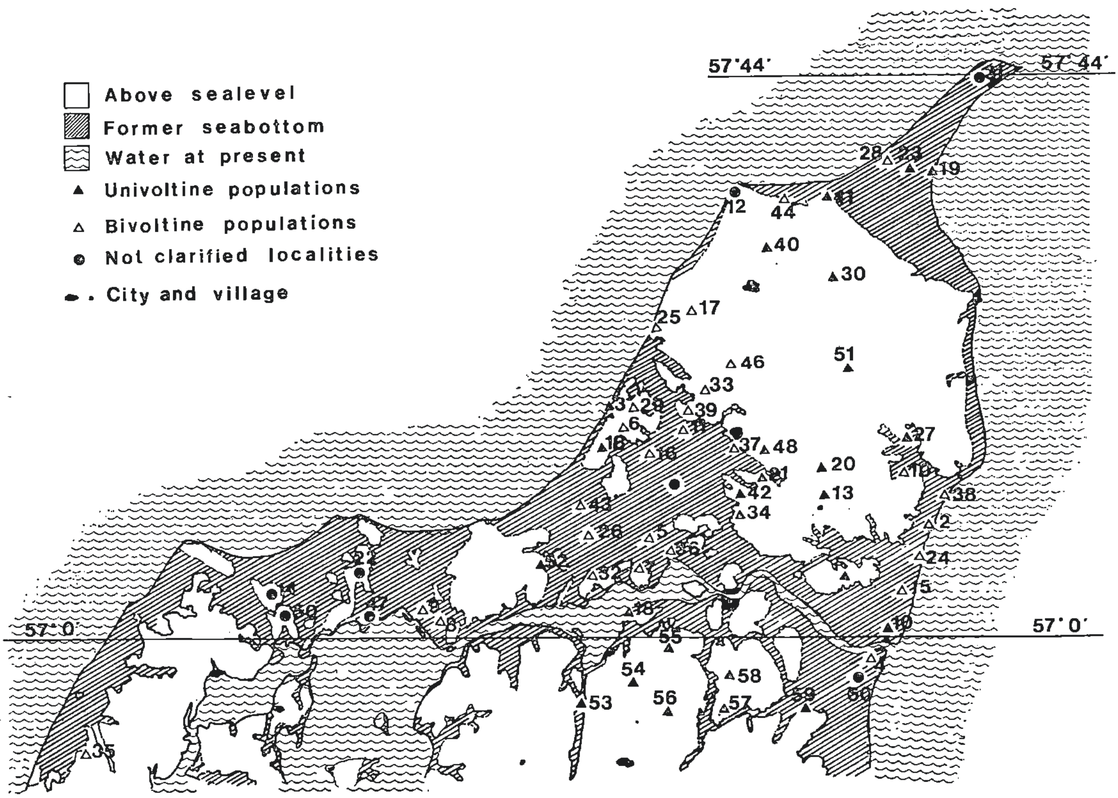

Fig. 4. 61 localities in the northern part of Jutland. The distribution of the 2 types cannot be explained by different types of soil. The reason for the presence of the deviating type is still unknown. (Copy of A. Jensen: Extension of the Stone Age Sea. Danm. Geol. Unders. II 35 1920).

Finland partly developed a 2nd generation in 1960, but it was considered an exception.

As already mentioned, the third type is considered a mixture of the two other types. The following example supports this theory: On 28, October 1961 a small number of fully grown larvae was collected at 2 localities on the east coast (nos. 2 and 24 in figure 4). The larvae pupated soon after collection and the pupae hibernated in the insectarium at Lyngby under approximately natural temperature conditions.

The 1962 hatching showed surprising results. The individuals from Aså (no. 2 in figure 4) hatched during the period May 21—June 19, whereas those from Melholt (no. 24 in figure 4) hatched in August, between 13th and the 28th. The 2 localities in question are very alike and the distance between them is only about 5 km. It should be added that both localities have been investigated thoroughly, and a great number of hatchings have revealed the presence of a bivoltine population at the farm at Melholt where the late developing specimens were collected.

This is sufficient to prove the existence of 2 biologically different types at Melholt and though there is no evidence to support this, it would seem that the reason for the very scattered appearearance of fly populations from several localities is the presence of the two types (see also the last part of this paper).

Hylemya floralis Fall. in Zealand

As this species is so closely confined to sandy soils, as mentioned above, it is no wonder that it is absent from most parts of eastern Denmark since the soil there is clayey. It was therefore surprising to find the species in Zealand, and it was also astonishing to learn how limited the attacks were. In spite of careful searching it was found at 3 localities only, see figure 1, and at these places it was only attacking horse-radishes grown on soils with a rather high humus content.

In experiments it has been shown that the offspring of flies developed on horse-radish can develop on swede turnips, but it appears that this will not occur spontaneously in the field, thus indicating a very strong host-preference.

Biologically, the populations found at the 3 localities in Zealand are typically bivoltine as is the deviating type in the northern part of Jutland. Whether these occurrences should be considered relics from the post-glacial age is not clear, but the horse-radish is not a plant native to Denmark. Thus *H. floralis* cannot have developed on this host in the remote past.

To complete the distribution survey, some discoveries in 1966 of *H. floralis* on the island of Amager (South of Copenhagen) should be mentioned. Pupae were collected at 6 different places at the beginning of May. The imagines started hatching in June (21 per cent) continued throughout July (68 per cent) and ended in August (11 per cent). The hatching period indicates the presence of the same deviating type as that found in northern Jutland and in Zealand, but the number of individuals is rather small (about 400 flies) and the investigations were carried out for one year only. Consequently the life cycle of these populations is not adequately known.

Could the two types be different species?

The question obviously arises, could the two types possibly be independent species? To determine this several hundred male adults were examined for morphological differences but no deviations were found.

Investigations were then made, whether the types could interbreed. The procedure followed was to force hatching of imagines of the univoltine type by placing the pupae at temperatures of approximately 20° C from the beginning of February. Hatching then took place in June, at the same time the 1st generation of the bivoltine type appeared.

Fig. 5. Breeding cages for "hybrids" of the 2 types.

Another possibility applied in most cases was to mate adults of second generation of the bivoltine type with univoltines, which hatch at the same time, in late summer.

Usually 10—20 flies of each sex were placed on a small cage with one swede turnip grown in a big flower-pot, see figure 5.

Of 60—70 experiments, about 40 of the crossings resulted in offspring whose life cycles were checked for one or more generations. In most cases the flies of the F_1 generation developed later than those of the 1st generation of the bivoltine but earlier than the parents of the univoltine type, see figure 6.

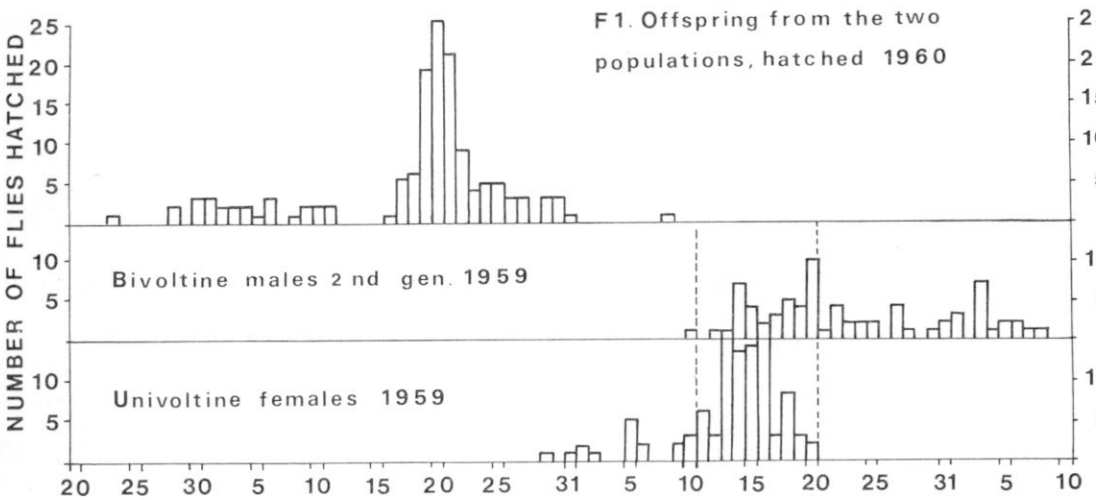

Fig. 6. Crossing the 2 types. The females originated from a univoltine population from which pupae were collected at Saustrup (see Fig. 1) October 30, 1958. The males originated from larvae collected at Aså (see Fig. 1) July 8, 1959. The specimens for interbreeding were hatched during the period framed with dotted lines.

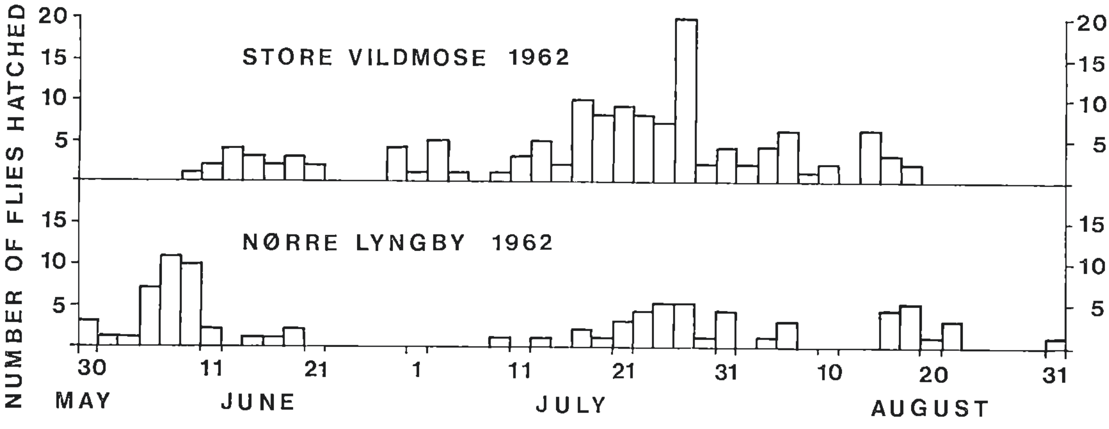

Fig. 7. Extremely scattered hatching of *H. floralis* Fall. (imagines) at 2 localities in Jutland (see Fig. 1). (Each column shows the number of flies hatched within 2 days). Nørre Lyngby: Pupae collected October 27th 1961. Store Vildmose: Pupae collected October 27th 1961. Hibernation and hatching in an insectarium at Lyngby (near Copenhagen).

Although the results are not adequate to explain the whole story, some conclusions could be drawn from them. Firstly the fact that the FI generations are able to interbreed and secondly the presence of fertile offspring in one or more succeeding generations supports the theory that the 2 types belong to the same species.

Furthermore, the life cycles of the "hybrid" populations indicate the probability of the third type being a mixture of the 2 types.

This means that the very scattered appearance demonstrated in figure 7 could be attributable to the 2 biologically different types living in the same habitat without interbreeding or the presence of "hybrids" from interbreeding. Further investigations are needed to establish to what extent these alternatives actually occur.

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Jørgen Jørgensen
The Royal Veterinary and Agricultural University, Copenhagen
Bülowsvej 13,
DK-1870 København V, Denmark

SELOSTUS

Ison kaalikärpäsen (Hylemya floralis Fall.) biologisista erikoispiirteistä Tanskassa

Jørgen Jørgensen

Kgl. Veterinaer- og Lanbohøjskole, København

Isoa kaalikärpästä (*Hylemya floralis*) on tavattu Tanskassa harvaa poikkeusta lukuun ottamatta vain hietamailla. Aikuisten kuoriutuminen talvehtineista koteloista alkaa normaalisti heinäkuun lopulla, on runsaimmillaan elokuussa ja jatkuu syyskuulle. Lajilla on vain yksi sukupolvi vuodessa. Kapealla maantieteellisellä vyöhykkeellä Jyllannin pohjoisosassa on lajin kehityksessä todettu poikkeavuuksia. Poikkeava tyyppi aikuistuu huomattavasti aikaisemmin, ja useissa tapauksissa kehittyy kaksi sukupolvea. Edellisten lisäksi on tavattu kolmatta kehitystyyppiä, jota pidetään ensiksi mainittujen tyyppien sekoituksena. Poikkeavan tyypin levinneisyys on rajoittunut Jyllannin pohjoisosaan sekä muutamille paikkakunnille Tanskan sisäosassa.

Risteyttämällä keskenään yksi- ja kaksisukupolvisten tyyppien yksilöitä saatiin fertiilejä jälkeläisiä. Näiden elämänkulku vahvisti käsitystä välityypin olemassaolosta. Syitä poikkeaviin erikoispiirteisiin ei voitu riittävästi selvittää.

ANNALES AGRICULTURAE FENNIAE, VOL. 15: 24—33 (1976)
Seria ANIMALIA NOCENTIA N. 76 — Sarja TUHOELÄIMET n:o 76

EFFECT ON YIELD OF DAMAGE CAUSED BY MELIGETHES AENEUS F. (COL.) TO WINTER RAPE, AS INDICATED BY CAGE EXPERIMENTS

EDVARD SYLVÉN and GUNNAR SVENSSON

SYLVÉN, E. & SVENSON, G., 1976. **Effect on yield of damage caused by *Meligethes aeneus* F. (Col.) to winter rape, as indicated by cage experiments.** Ann. Agric. Fenn. 15: 24—33. (Nat. Swed. Inst. Plant Prot., S-17107 Solna 7, Sweden)

The effect on yield of damage caused by the Blossom Beetle, *Meligethes aeneus* F., was studied in four cage experiments in fields of winter rape in Central Sweden. It was found that damage was to a considerable extent compensated by the plants developing new flowers and pods. Despite this, in some of the experiments the data indicate a clear loss in yield following beetle attacks.

Index words: *Meligethes aeneus* F., *Brassica,* rape, power of compensation in plants, economic significance.

Introduction

In large parts of Europe the Blossom Beetle (*Meligethes aeneus* F.) is considered a major pest in various cruciferous crops grown for seed production. Rape and turnip rape, for example, are often attacked badly. Large numbers of flower buds may be destroyed by adult beetles feeding on them. The main damage occurs before any flowers have opened on the plants.

However, certain data have been published indicating that cruciferous plants have a remarkable power of compensation. WINFIELD (1962), for example, found that Brussels sprouts and trowse mustard gave a quantitatively normal seed yield even after considerable numbers of flower buds had been removed. As cage experiments conducted by KAUFMANN (1942) showed, rape also has great capacity for recovery: loss of flower buds is counteracted by the formation of new buds.

Nevertheless, although the crop has a remarkable power to compensate, attacks by beetles may lead to distinct deterioration in yield. This is demonstrated by the figures obtained in a cage experiment with winter rape carried out in Central Sweden in 1966 (SYLVÉN 1968).

The cage experiments reported below were performed to further elucidate the relationship between damage caused by the beetle and the quantity and quality of seed yield in winter rape. The experiments took place in 1968—1971 on the island of Svartsjölandet in Lake Maelar, Central Sweden.

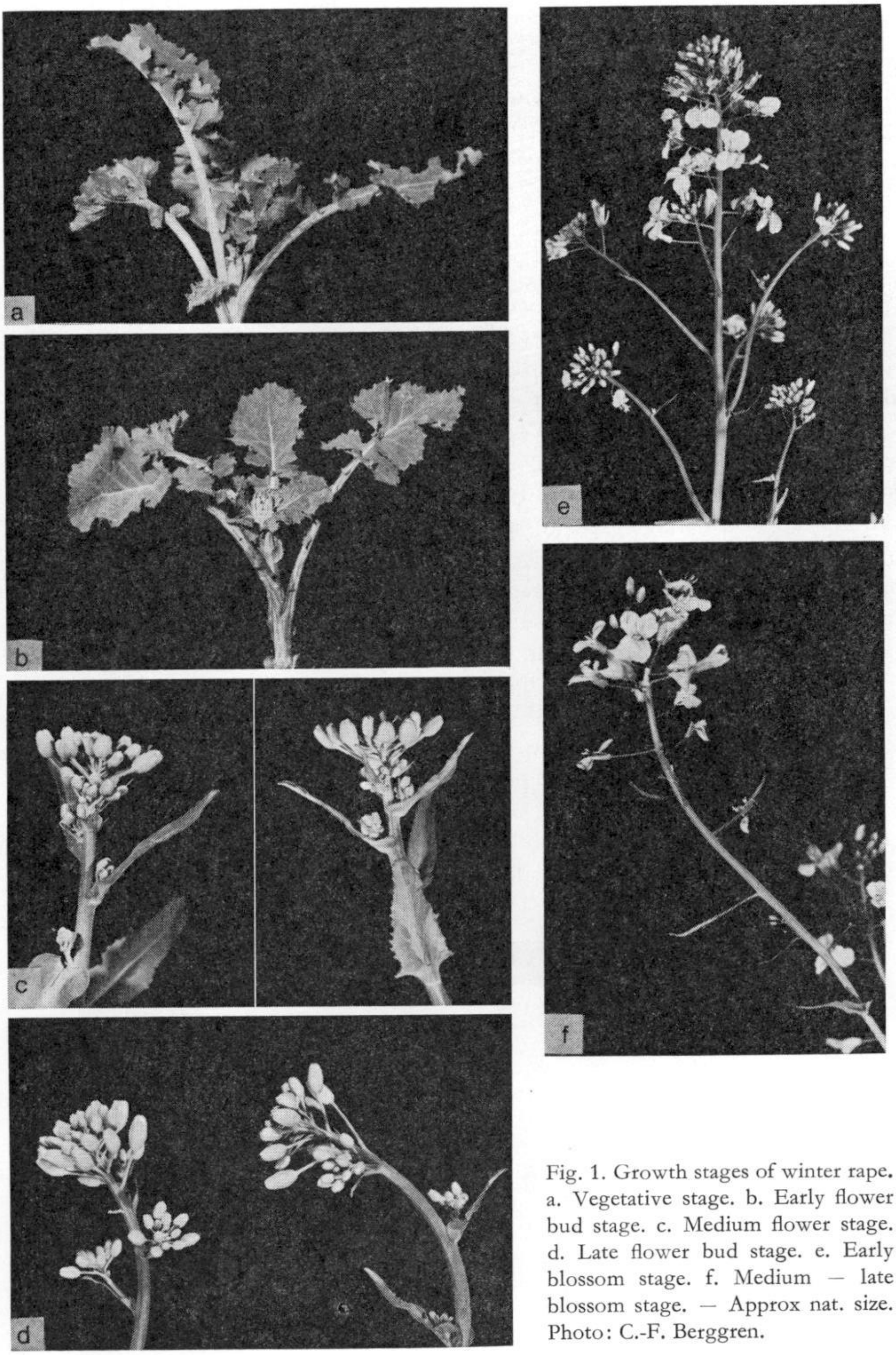

Fig. 1. Growth stages of winter rape. a. Vegetative stage. b. Early flower bud stage. c. Medium flower stage. d. Late flower bud stage. e. Early blossom stage. f. Medium – late blossom stage. – Approx nat. size. Photo: C.-F. Berggren.

Table 1. Growth stage key for rape and turnip rape.

Stage	Definition	Rank scale
Vegetative	No flower buds yet visible	1
Early flower bud	Flower buds in dense agglomerations; no flower buds yet completely free	2
Medium flower bud	One or more flower buds completely free; flower buds show no sign of yellow	3
Late flower bud	One or more flower buds show yellow; as yet no open flowers	4
Early blossom	One or more open flowers; as yet no pods	5
Medium — late blossom	One or more open flowers, also one or more pods	6
Post-blossom	Pods, no flowers	7

Growth stage key for Brassica seed crops

The key shown in Table 1 was developed to classify the growth stages in rape and turnip rape. Photographs showing growth stages are reproduced in Fig. 1.

Using the rank scale, the growth stage of crop can be adequately distinguished. If, for example, half the total number of plants are in the vegetative stage (rank 1) and the remaining plants in the early flower-bud stage (rank 2), then the crop is considered to be at growth stage 1.5, i.e. the mean of the points referring to the separate plants.

A growth stage key for rape published recently by BERKENKAMP (1973) is more detailed, but otherwise coincides in the main with that presented in Table 1.

Methods

All the experiments were carried out in ordinary fields of winter rape belonging to different farmers.

In all the years the cages were erected as early as possible in the spring, as soon as weather and field conditions permitted. The growth stage of the crop was at that time 1—2. The earliest date for mounting the cages was 18 April (1968), the latest 13 May (1970). The cages were dismounted when crops had reached growth stage 4—5.

Fig. 2. Type of cage used in the experiments. Photo: C.-F. Berggren.

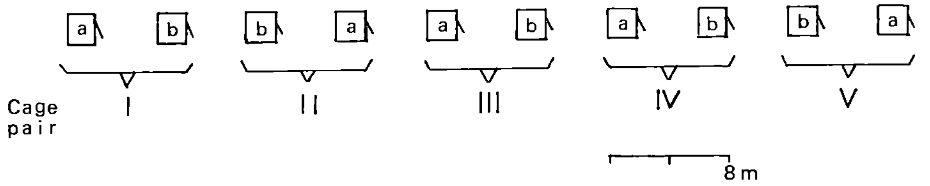

Fig. 3. Map showing arrangement of cages in the 1968 experiment.
a. Beetles not introduced. b. Beetles introduced.

The number of cages was increased from 10 in 1968 and 1969 to 16 in 1970 and 1971. The cages (5 × 2) were mounted one after the other in the first two years, while in the two remaining years they were distributed according to a Latin square system (4 × 4).

All cages (Fig. 2) were the same size (1.9 m long by 1.8 m wide and 1.9 m high). They consisted of wooden frames and a synthetic fibre net. The mesh size (c. 0.6 mm) was fine enough to prevent the beetles from passing through.

The plant stand was adjusted by thinning out soon after the cages were mounted (before the beetles were introduced; cf. below). After adjustment, the number of plants in each of the two cages in the separate cage pairs was identical (cf. Fig. 3) in the 1968 and 1969 experiments. However, the number of plants per cage varied between the cage pairs, in 1968 from 166 to 275, and in 1969 from 121 to 158. On the other hand, in the 1970 and 1971 experiments the plants were thinned to allow an identical number in each of the 16 cages, 125 plants in each cage in 1970 and 79 in each cage in 1971.

The map, Fig. 3, shows the arrangement of the cages in the 1968 experiment. No beetles were introduced in five cages, while each of the remaining five were supplied with 10 beetles per plant during the pre-blossom period, from 29 April up to and including 6 May. On 29—30 April, when 7 beetle specimens per two rape plants were placed in the cages, the growth stage of the crop in the cage plots was approx. 2 or less.

The arrangement of the 1969 experiment was the same in principle as that in 1968. In five cages no beetles were introduced, while six beetles per plant were placed in each of the five additional cages. The beetles were introduced 12—13 May, when the crop in the cages was at growth stage approx. 2 or less.

In the 1970 experiment four cages received no beetles while the remaining cages received six beetles per plant on 14—15 May (four cages), 19 May (four cages) and 25 May (four cages). As indicated by detailed counts, the growth stage of the crop (not damaged by beetle) in the cages corresponded to 1.6 (14 May), 2.1 (19 May) and 3.0 (25 May).

The map, Fig. 4, shows the arrangement in the 1971 experiment. In principle, the cages were distributed in the same way as in 1970.

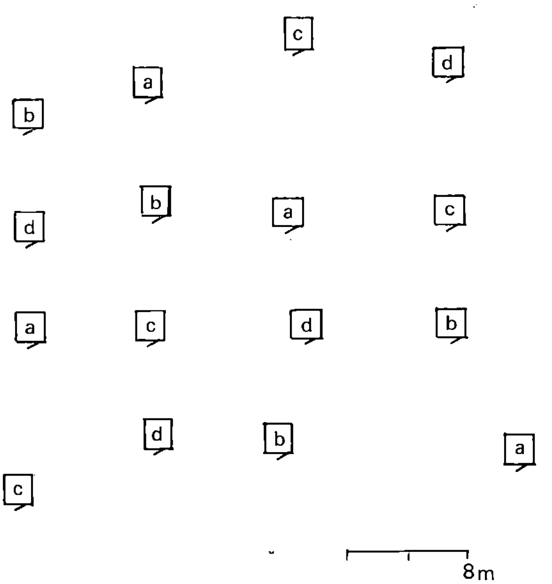

Fig. 4. Map showing arrangement of cages in the 1971 experiment. a. Beetles not introduced. b. Beetles introduced on 11 May. c. Ditto on 14 May. d. Ditto on 17 May.

Table 2. Cage experiments, 1969—1971. Counts of number of beetles on the plants.

Beetles introduced[1]	Counts made	No. of cages examined	No. of plants examined[2]	Beetles on the plants Mean per plant
		1969 experiment		
12—13 May	19 May	5	600	3.3
12—13 »	29 »	2	236	4.8
		1970 experiment		
14—15 May	27 May	4	500	2.4
19 »	28 »	4	513	2.6
25 »	29 »	4	503	3.5
14—15 »	1 June	4	500	2.2
19 »	1 »	4	514	2.3
25 »	1 »	4	503	2.1
		1971 experiment		
11 May	17 May	4	314	2.2
14 »	17 »	4	314	3.1
17 »	19 »	4	310	2.6
11 »	24 »	4	316	1.7
14 »	24 »	4	312	1.9
17 »	24 »	4	313	1.7

[1] Six beetles introduced per plant, in each cage.
[2] The intention was to examine all the plants in the cages. It is evident from the figures, however, that certain plants were overlooked. Moreover, a few plants may have been checked twice by mistake.

Four cages received no beetles; the remaining cages six beetles per plant on 11 May (four cages), 14 May (four cages) and 17 May (four cages). The growth stage of the crop (not damaged by beetle) in the cages corresponded approximately to 2 (11 May) and according to detailed counts to 2.8 (14 May) and 3.4 (17 May).

The plants in the cage plots were harvested by hand. After drying, the oil seed was hand-threshed and cleaned on a special cleaning machine. The oil seed was weighed and sent to the Swedish Seed Association at Svalöf for quality analysis.

Number of beetles on the plants

On various occasions large numbers of the beetles introduced were observed resting on the sides of the cages. It was therefore considered worthwhile studying how many beetles happened to be simultaneously on the plants.

Table 2 shows the results of comprehensive counts performed in cages supplied with beetles in the 1969—1971 experiments. In the most of the examinations the occurrence of beetles on the plant stand was found to be about 1/3 or 1/2 of the number of beetles introduced, i.e. about 2 or 3 specimens per plant.

Incidence of attack by *Dasineura brassicae* Winn.

Tables 3—4 show the results of counts of attack by the Brassica Pod Midge, *Dasineura brassicae* Winn.

The figures for the 1969 experiment indicate a high incidence of attack by the midge. However, counts during that year were made late in the season when the pods on the plant stand had already begun to ripen. This caused difficulties in estimating the extent of the midge attack, and for this reason the figures cannot be considered entirely reliable.

Table 3. Cage experiment, 1968—1969. Attack by Brassica Pod Midge (*Dasineura brassicae* Winn.) per 10 plants. Means per cage.

Test series	Pods attacked, % 22—24 July, 1968	Pods attacked, % 27 June and 7 July, 1969[1]
Beetles not introduced	20	5[2]
Beetles introduced	20	11[3]

[1] Plots of one pair of cages examined on 27 June, remaining plots on 7 July

[2] One of the five figures referring to the separate cages based on counts of 9 plants only.

[3] Two of the five figures referring to the separate cages based on counts of 9 plants only.

To continue with the 1969 experiment, Table 3 shows that the midge attack was minor or moderate. It is of interest to note that the figures for the cage plots supplied with beetles are lower than those for the remaining cage plots. Possibly, delay in the development of plants in the plots where beetles were introduced prevented the plant stand from reaching a suitable growth stage for the midge to oviposit until its first flight was declining.

In the 1970 and 1971 experiments, midge attack was negligible in all cage plots (Table 4).

Compensation power in plants

In the 1969 experiment the number of open flowers and/or pods was counted on various occasions, taking random samples of plants outside and inside the cage plots. The diameter of the stem (5 cm above stem basis) was also measured on each plant.

A total of 40 plants were counted in each plot series (10 plants in each of four plots outside /between/ the cages, or 10 plants in each of four cages). However, the data for one or two plants in each series are incomplete and therefore omitted below. Moreover, in order to facilitate statistical treatment, one additional plant is deleted in each of the series showing complete figures for 39 plants. Deletion was performed using a chart of random numbers.

Thus, 38 plants remain in each series. Using coveriance analysis (SNEDECOR and COCHRAN, 1967, p. 420—424), means of the number of flowers & pods, or pods only, weighted against the stem diameter (mm) were calculated. Table 5 shows a survey of the figures.

As can be seen, the Blossom Beetle initially caused a sharp decrease in the number of flowers and pods. Later, however, there was remarkable compensation. The counts made in early July show no significant difference in the number of pods between the cage plots with and without beetles.

Also, in the remaining experiments, counts (number of pods) and measurements (stem diameter 5 cm above stem basis) were performed, taking random plant samples. This was done in late June or early July.

In each cage plot series, 50 (1968 experiment)

Table 4. Cage experiments, 1970—1971. Atteck by Brassica Pod Midge (*Dasineura brassicae* Winn.) per 10 plants. Means per cage.

Test series 1970	Test series 1971	Pods attacked, % 3—9 July, 1970	Pods attacked, % 12 July, 1971
Beetles not introduced		4	3
Beetles introduced on			
14—15 May	11 May	3	4
19 »	14 »	1[1]	4
25 »	17 »	4[1]	4

[1] On of the four figures referring to the separate cages based on counts of 9 plants only.

Table 5. Weighted means of number of open flowers and pods (9, 12, 18—19 June) or pods (27 June—7 July) in plants from cage plots in the 1969 experiment. Each mean refers to 38 plants. For further explanation cf. text.

Sampling date (s)	Outside cage plots A	Beetles not introduced B	Beetles introduced C	Diff.[1] A—B	A—C	B—C
9 June	22.9	19.1	2.3	ns	***	***
12 »	47.0	44.0	10.0	ns	***	***
18—19 »	122.1	117.3	89.4	ns	*	*
27 June—7 July	74.2[2]	95.0	91.3	*	ns	ns

[1] ns, not sign.; *, sign. at 5 % level; ***, sign. at 0.1 % level.
[2] Despite the fact that all flowers do not normally develop into vigorous pods, this figure is unexpectedly low. No clear explanation for this is indicated by the available data.

or 40 (1970 and 1971 experiments) plants were included. However, for reasons similar to those mentioned above, certain plants in the 1970—1971 samples are not taken into consideration below. In excluding these plants, the same principles are followed, cf. above (1969 experiment).

Table 6 shows the weighted means calculated by coveriance analysis (SNEDECOR and COCHRAN; cf. above). The figures provide further strong evidence that winter rape has an extremely high power of compensation in the face of damage caused by Blossom Beetle. With one exception (number of pods higher /!/ in the cage plots with beetles), there is no significant difference in the number of pods between plots with and without beetles.

Yield of crop in cages

Tables 7—9 give a summary of the yield of crop in the cages.

Beginning with the 1968—1969 experiments, it can be seen (Table 7) that the quantity of yield was significantly less in the cage plot series with beetles than in the series without

Table 6. Weighted means of number of pods in plants from cage plots in the 1968, 1970 and 1971 experiments. For further explanation cf. text.

Year	Sampling date (s)	No. of plants	Beetles not introduced	Beetles introduced[1]	Diff.[2]
1968	22—24 July	50	66.8	75.1	ns
1970	3—9 »	39	54.4	77.9	***
		39	54.4	59.8	ns
		39	54.4	56.9	ns
1971	21 June	38	82.1	71.8	ns
		38	82.1	77.6	ns
		38	82.1	72.2	ns
1971	30 June	38	82.9	86.8	ns
		38	82.9	86.2	ns
		38	82.9	78.0	ns
1971	7 July	38	81.8	97.8	ns
		38	81.8	91.7	ns
		38	81.8	88.0	ns

[1] For 1970, the upper, middle and lower figures refer to plots with beetles introduced on 14—15, 19 and 25 May respectively. For 1971 (each sampling date), the corresponding figures refer to plots with beetles introduced on 11, 14 and 17 May respectively.
[2] Cf. footnote 1, Table 5.

beetles. Moreover, there was a tendency towards a lower oil content and higher chlorophyll content in the plots where beetles had been introduced. The value in money per cage was about 20 % (1968) or 10 % (1969) lower in the series with beetles than in the series without.

In the 1970 experiment (Table 8), the data

Table 7. Yield in the cage experiments, 1968—1969. Means per cage.

Kind of data	1968 experiment Beetles not introduced	Beetles introduced	Diff.[1]	1969 experiment Beetles not introduced	Beetles introduced	Diff.[1]
1000-kernel wt. (g)	4.4	4.7	ns	4.7	4.8	ns
Yield adjusted to 18 % water content (g)	1020	806	*	862	771	*
Oil (%)	48.7	48.1	ns	45.2	44.5	*
Free fatty acids (%)	0.4	0.4		0.2	0.2	
Chlorophyll (ppm)	6	7	*	7	9	ns
Value in money[2] (Swedish öre)						
Per kg	118	117	ns	115	114	*
Per cage	107	84	*	88	80	*

[1] ns, not sign.; *, sign. at 5 % level.
[2] Price level of 1973.

Table 8. Yield in the cage experiment, 1970. Means per cage.

Kind of data	Beetles not introduced A	Beetles introduced on 14—15 May B	19 May C	25 May D
1000-kernel wt. (g)	5.7	5.3	5.1	5.5
Yield adjusted to 18 % water content (g)	667	728	677	596
Oil (%)	44.6	43.3	43.3	43.1
Free fatty acids (%)	0.5	0.6	0.6	0.6
Chlorophyll (ppm)	10	16	17	16
Value in money[1] (Swedish öre)				
Per kg	113	111	111	111
Per cage	67	72	67	59

Analysis of variance for Latin square (SNEDECOR and COCHRAN 1967, p. 312—317) shows significance for each kind of data except free fatty acids. Differences among the means according to Student Newman-Keul's test (SNEDECOR and COCHRAN 1967, p. 273—274) are characterized as follows (ns, not sign.; *, sign. at 5 % level; **, sign. at 1 % level):

	A—B	A—C	A—D	B—C	B—D	C—D
1000-kernel wt. (g)	ns	*	ns	ns	ns	ns
Yield adjusted to 18 % water content (g)	ns	ns	*	ns	**	*
Oil (%)	*	*	*	ns	ns	ns
Chlorophyll (ppm)	**	**	**	ns	ns	ns
Value in money[1] (Swedish öre)						
Per kg	*	*	*	ns	ns	ns
Per cage	ns	ns	*	ns	**	*

[1] 1973 price level

Table 9. Yield in the cage experiment, 1971. Means per cage.

Kind of data	Beetles not introduced	Beetles introduced on 11 May	14 May	17 May
1000-kernel wt. (g)	5.4	5.4	5.5	5.4
Yield adjusted to 18 % water content (g)	580	563	576	515
Oil (%)	46.0	43.9	45.5	46.0
Free fatty acids (%)	0.5	0.6	0.6	0.5
Chlorophyll (ppm)	13	18	15	14
Value in money[1] (Swedish öre)				
Per kg	115	112	114	115
Per cage	59	57	58	52

[1] 1973 price level

indicate no clear relationship between beetle occurrence and quantity of yield. It is true that the plot series with beetles introduced on 25 May gave a significantly lower quantity than each of the remaining plot series, but the reason for this need not necessarily be connected with the beetle attack. However, there was a tendency towards a lower oil content and higher chlorophyll content in yield in the plots where beetles had been introduced.

The yield data of the 1971 experiment (Table 9) indicate no clear effect of the beetle upon yield. Statistical analysis of the data was performed according to the same methods as indicated in Table 8. Variation within the plot series was found to be considerable, and there are no significant differences between the series either in quantity or quality of yield.

Conclusions

In close agreement with earlier experience, the damage caused by Blossom Beetle in the experiments was counteracted in the winter rape plants by a substantial formation of new flowers and pods. Despite this, the results clearly indicate a loss in yield caused by the beetle in the 1968—1969 experiments, and to a certain degree also in the 1970 experiment. However, possibly as a consequence of high variation in yield within the separate plot series, the data reveal no significant effect of the beetle upon yield in the 1971 experiment.

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Edvard Sylvén[1] and Gunnar Svenson
National Swedish Institute for Plant Protection
S-17107 Solna 7, Sweden

[1] Present adress:
Swedish Museum of Natural History
Section of Entomology
S-10405 Stockholm, Sweden

SELOSTUS

Rapsikuoriaisen (Meligethes aeneus F., Col.) vaikutus syysrypsin tuhoihin häkkikokeiden perusteella

EDVARD SYLVÉN ja GUNNAR SVENSSON

Statens Växtskyddsanstalt, Sverige

Rapsikuoriaisen (*Meligethes aeneus* F.) vaikutusta syysrypsin satoon tutkittiin Keski-Ruotsissa häkkikokeiden avulla. Tutkimuksissa todettiin, että kasvit kompensoivat huomattavassa määrin kuoriaisten aiheuttamaa vioitusta kasvattamalla lisää kukkia ja lituja. Tästä korvauskasvusta huolimatta aiheuttivat kuoriaiset joissakin kokeissa selvästi todettavia satotappioita.

ANNALES AGRICULTURAE FENNIAE, VOL. 15: 34—55 (1976)

Seria ANIMALIA NOCENTIA N. 77 — Sarja TUHOELÄIMET n:o 77
Seria PHYTOPATHOLOGIA N. 61 — Sarja KASVITAUDIT n:o 77

MEGADELPHAX SORDIDULA (STÅL) (HOM., DELPHACIDAE) AS A VECTOR OF PHLEUM GREEN STRIPE VIRUS

OSMO HEIKINHEIMO and MIKKO RAATIKAINEN

HEIKINHEIMO, O. & RAATIKAINEN, M. 1976. **Megadelphax sordidula (Stål) (Hom., Delphacidae) as a vector of Phleum green stripe virus.** Ann. Agric. Fenn. 15: 34—55. (Agric. Res. Centre, Inst. Pest Inv., SF-01300 Vantaa 30, Finland).

Megadelphax sordidula (Stål) transmits a hitherto unknown virus-like disease agent, referred to here as the *Phleum* green stripe virus (PGSV). It attacks spring cereals and timothy (*Phleum pratense* L.) producing light green to yellowish stripes and streaks of varying size in the leaves as well as weakening the growth of the plants and decreasing the grain yield. The proportion of vectors among *M. sordidula* in different aged timothy stands may exceed 40 %. The incubation period of PGSV in planthoppers was 28—33 days, and in plants 10—(18)—40 days. The shortest positive inoculation feeding time observed was 6 hours.

M. sordidula is most abundant in South and South-east Finland. The species is probably most harmful as a virus vector in old timothy leys on mineral soils in South and South-east Finland as well as in spring cereals in the same districts.

Index words: planthopper, *Phleum*, cereals, virus, economic significance.

INTRODUCTION

During 1955—65 studies were made at the Department of Pest Investigation of damage to spring cereals caused by different planthopper species. In laboratory trials during 1962 some hitherto unknown virus-like symptoms we discovered on oats sucked by the planthopper *Megadelphax sordidula* (Stål). The injuries differed from those of oat sterile dwarf (OSDV) (CATHERALL 1970, IKÄHEIMO 1961, LINDSTEN 1959, 1961 a, 1961 b, 1973, PRŮŠA 1958, PRŮŠA et al. 1959, VACKE 1960, VACKE and PRŮŠA 1959), european wheat striate mosaic (EWSMV) (IKÄHEIMO 1960, LINDSTEN 1959, 1961 a, 1961 b, PRŮŠA and VACKE 1960, SLYKHUIS and WATSON 1958, VACKE and PRŮŠA 1961, WATSON and SINHA 1959), oat pseudo-rosette disease (SUKHOV and VOVK 1938, ZAZHURILO and SITNIKOVA 1939, 1940), maize rough dwarf (MRDV) (HARPAZ et al. 1965, LINDSTEN et al. 1973), blue dwarf of tall oat grass (KEMPIAK 1972, MÜHLE and KEMPIAK 1971, VACKE 1966), *Dubia* disease of barley (KEMPIAK 1972), and cereal tillering disease (CTDV) (LINDSTEN 1974 a, 1974 b, 1975, LINDSTEN et al. 1973), all of which are transmitted in Europe by planthoppers, but none by *M. sordidula*. At the same time NUORTEVA (1962) announced some virus-like symptoms caused by *M. sordidula* in oats grown under unfavourable conditions. In our trials with spring cereals and ley grasses in 1963—65 it appeared that *M. sordidula* could cause similar symptoms in spring cereals and timothy (*Phleum pratense* L.). To date, attempts to infect timothy with viruses transmitted by planthoppers have been successful only with EWSMV (KEMPIAK 1972, VACKE and PRŮŠA 1961), MRDV (KEMPIAK 1972), and CTDV (LINDSTEN 1974 b, LINDSTEN et al. 1973). In addition, LINDSTEN (1961 b) reported virus symptoms resembling EWSMV on timothy grown in the field.

Very few studies have been made of toxic injuries on gramineous plants caused by *M. sordidula* (NUORTEVA 1962), or its role as a vector of virus-like disease agents (BREMER 1974, RAATIKAINEN 1970, VACKE 1962).

The bionomics of *M. sordidula* were investigated in connection with disease studies. Some of the results of the ecology have been published earlier (e.g. RAATIKAINEN 1960, 1961, 1970, 1971, 1972, RAATIKAINEN and VASARAINEN 1971, 1973, 1976).

MATERIAL AND METHODS

Tests of injuries

Tests with planthoppers were made sowing the test plants in 430 × 250 × 120 mm wooden boxes lined with polyethylene film (Fig. 1). The bottoms of the boxes were perforated for to allow drainage. The boxes were filled to a depth of 110 mm with steamed and limed soil, fertilized with multiple fertilizer. Test plants' seeds were sown in 6 parallel rows, 4 seeds to each row, at equa distances from one another and at a depth of 30 mm. During test feeding times each planthopper was caged with one seedling under a cylinder of PVC plate, 30 mm in diameter and 250 mm tall, the upper end of which and two ventilation openings near the bottom were covered with gauze. Control plants were caged in the same manner. Observations were made at least once a week for any symptoms

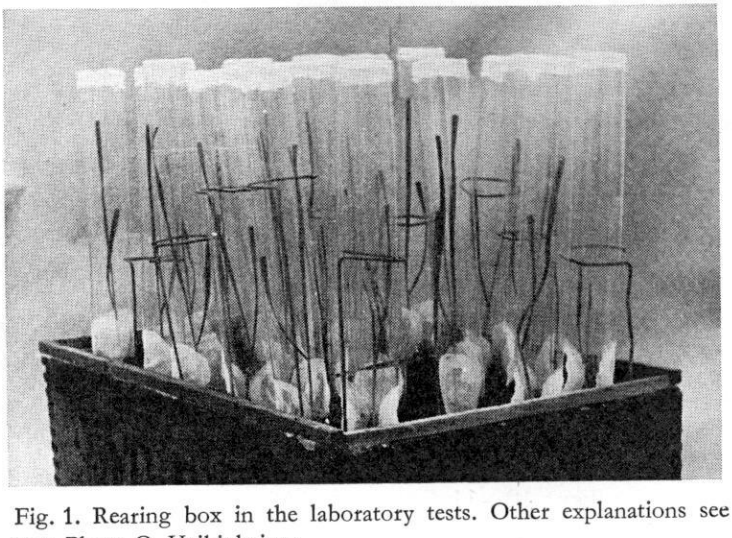

Fig. 1. Rearing box in the laboratory tests. Other explanations see text. Photo O. Heikinheimo.

of disease. Several characteristics noted on the test plants were measured against the mature plants.

The planthoppers used in the trials were either collected immediately before the trials from fields of timothy or cereals or they had been reared and kept on oats or timothy growing in 150 mm flower pots, and isolated by gauze (Raatikainen and Tinnilä 1959, Fig. 1).

In 1963, planthopper nymphs were collected in four different localities (page 43). From these localities, two sets of very poorly material were collected in April (Nos. 1 and 2) and consisted of hibernated 2—3 stage *M. sordidula* nymphs, and the other sets (Nos. 3 to 6) were collected on June 13, and consisted of distinctly more planthoppers, mostly adults. Using these materials, five successive tests were conducted in the greenhouse between June 14 and July 16.

In 1964, the tests were again conducted in the greenhouse but after inoculation feedings the test plants were kept in outdoor isolation chambers with screened walls, until mature. In the last series of trials, however, the plants were kept in the insectary the entire time. The planthoppers used were collected from a 3rd year timothy ley located at Kalanti (Grid 27°E: 675: 20, Heikinheimo and Raatikainen 1971). Besides timothy, the ley contained many other grasses such as *Poa*, *Agrostis*, *Deschampsia* etc. Two different series of inoculation tests were performed. Firstly, with the 231 2—3 stage nymphs collected on April 14, when the snow was in its final stages of melting. Two consecutive infection tests on oats were made on April 17 and 24, with 7 and 6 day feeding times. After this, the infective planthoppers were used in an infection time trial and a symptom trial with certain grass species. The planthoppers which proved to be non-infective were subsequently tested in an acquisition feeding test in the following manner: 22 of them were kept 10—11 days on infected oat plants, and 16 of them the same time on healthy plants. Wherever possible, the infectiveness of both planthopper groups was tested in 9 consecutive tests. Secondly, *M. sordidula* planthoppers collected on June 10 at the same place as before were divided into two groups. One group was kept 12 days for acquisition feeding on infected oat plants, the other, at the same time, was fed individually on healthy oat plants. Both groups were then tested as above, though they had not previously been tested for infectiveness before the trial. Seven consecutive infection tests were made with 165 planthoppers. The inoculation feeding times varied between 4 and 11 days. In addition to oats, barley and spring wheat were used as test plants. A symptom trial with the tested infective planthoppers was also performed on timothy. Toxic injury was determined by comparing apparently healthy oat plants fed on by one *M. sordidula* for 4—5 days with plants which had been caged without planthoppers for the same length of time. At the start of the trial, the plants were at the one-leaf stage. In this trial there was a total of 35 control plants, 45 plants fed on by female planthoppers and 34 by male planthoppers (Table 4).

In 1965, the planthoppers to be tested were sampled from a 3rd year timothy ley in Vantaa (668: 39) in April. This material consisted of 2—3 stage nymphs of *M. sordidula* as well as *Dicranotropis hamata* (Bh.), which could only be identified with certainty after they emerged to adults during the tests. Acquisition tests were made in a greenhouse, and after 9 days' inoculation feeding the test plants were grown in an outdoor isolation chamber with screened walls. For acquisition feeding, the planthopper nymphs were divided into two groups, as in 1964. From this material 37 nymphs of *M. sordidula*, and 15 of *D. hamata* were tested after acquisition feeding on PGSV infected timothy, and 29 *M. sordidula*, and 6 *D. hamata* were tested after feeding on healthy timothy. Besides oats, several spring wheat cultivars and ley grass species were used in 9 successive tests.

The bionomics of M. sordidula

The bionomics of *M. sordidula* were investigated in the years 1956—1975. Its life cycle, food, natality and mortality were studied between 1956—1960 (RAATIKAINEN 1960, 1961). During the years 1957—1964 species' migration was investigated in West Finland near the city of Vaasa with the aid of netting apparatuses, and fluctuations in the abundance of the species were studied using suction apparatus, sweep net, and netting apparatus (RAATIKAINEN 1970) The suction apparatus, sweep net and netting apparatus have been bescribed by HEIKINHEIMO and RAATIKAINEN (1962) and RAATIKAINEN (1967). The occurrence of the species in different seasons and cereals as well as its migration from leys into cereal fields were also expounded during the same years (RAATIKAINEN 1971, 1972, RAATIKAINEN and VASARAINEN 1971, 1973).

The abundance of the species at the turn of June and July in oat fields throughout the country was investigated between 1962—1964. The material for this purpose was collected from 28 localities using sweep nets (Fig. 8). A sample of 60 sweeps from 14—26 fields was taken from each locality, 720 samples altogether. The material consisted of 68 932 adult leafhoppers, 1280 of which were *M. sordidula* (RAATIKAINEN and VASARAINEN 1976). At the turn of June—July 1966—1968 the netting samples were collected from leys in 54 localities (Fig. 7). Netting samples consisting of 60 sweeps were collected from 30 leys in each locality. The samples were taken from a total of 1080 hayfields. This material, also, consisted of more than 60 000 adult leafhoppers which included 2738 *M. sordidula*. In the years 1972—1974 netting samples were collected at the beginning of June from winter cereal fields in 18 localities. A netting sample of 60 sweeps was taken from 30 fields in each locality. Samples were collected from 540 winter cereal fields altogether. All of this material has not yet been identified. With the aid of suction apparatus and sweep nets, samples of leafhoppers were collected from 53 fields not under cultivation in Central Finland. This material consisted of 5 300 leafhoppers, including approximately 400 *M. sordidula*. In addition the species was being reared in the laboratory for several years. The whole material includes about 25 000 individuals of *M. sordidula*.

RESULTS

The injuries caused by M. sordidula

Symptoms of Phleum green stripe disease

The first symptom and the most distinct evidence of injury to oats produced by *M. sordidula* was the change in leaf coloration. On average 18 days after the planthoppers had been placed on oat seedlings at the two-leaf stage light green or yellowish green streaks and striations appeared, usually in the fourth leaf and often extending the entire length of the leaf (Fig. 2). Occasionally this discoloration appeared in the third leaf also, but never in older leaves which had stopped growing. At the same time the fifth leaf either became striped or almost entirely light-coloured, with normal green or dark green coloured streaks of varying width. The sixth leaf and occasionally the seventh leaf were — as soon as they had emerged — entirely or almost entirely pale-coloured, yellowish green or greenish yellow, and their basal part had streaks of normal green or dark green colour. In certain instances these colour changes occurred only in the 6th and 7th leaves. Such discoloured leaves were not more rigid than the corresponding healthy oat leaves, rather more were thus somewhat indolent, and lacked a tendency to curl into rolls. Simul-

Fig. 2. Leaves of 'Tammi' oats (above left), timothy (above right), and 'Apu' (below left) and 'Selkirk' (below right) spring wheats, infected with PGSV. Inoculation feeding time by *M egadelphax sordidula* 2—3 days at 2—3 leaf stages of plant seedlings. Photo O. Heikinheimo.

taneously, pale green areas appeared in all the remaining leaves except the oldest ones on the plant and in the tillers. Such pale areas extended through the thickness of the leaf and were thus similar on both sides. Their size and shape remained unchanged from the time they first appeared. The injury was not accompanied by heavy tillering nor by premature death of the plant.

In the 6-rowed barley cultivar 'Pirkka' pale green stripes of varying width appeared in the upper leaves. The difference in colour between the normal green and the pale stripes was less striking than that in oats; in some cases it was somewhat difficult to distinguish colour differences.

In spring wheat 'Apu' the symptoms of PGSV were very distinct and marked (Fig. 2). The streaks and stripes appearing in the leaves were long, sometimes extending along the entire blade and pale green or greenish yellow in colour. In early stages, the injury resembled very closely the initial symptoms of EWSMV. The youngest leaf emerged, the growing point, and the leaves within the sheath which had not emerged withered and died immediately after the appearance of the stripes. On the other hand, the old full-grown leaves, dark green in colour, remained alive for a long time, even longer than the uninfected plants. This phenomenon reveals a clear difference between the plants infected with PGSV and EWSMV, since the latter died within a short time, considerably before the wheat ripened. Since the growing point of the PGSV-infected plants was destroyed, no stem developed. In some of the plants, however, the injury remained so mild that a stem and spike developed. Such plants were only slightly shorter than normal, but with the exception of one spike in our trials, no grains were formed. The grains in this one spike were smaller than normal, and wrinkled (Fig. 3) but not shriveled (cf. PRŮŠA 1958, VACKE 1960), as are the grains of OSDV infected wheats and wheats mildly infected with EWSMV. When the injury caused by PGSV was severe, there were fewer shoots on the wheat plants than on healthy plants. In the other spring wheat cultivars tested, discoloration and inhibition of the growth were less pronounced (Fig. 2).

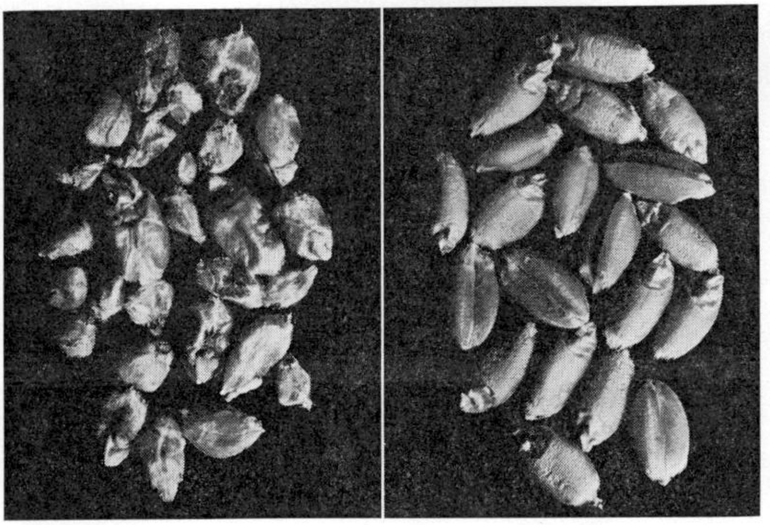

Fig. 3. The effect of the mildest PGSV infection on the grains of 'Apu' spring wheat. To the left wrinkled grains of an infected plant inoculated at 2-leaf stage, to the right grains of a healthy-looking wheat plant growing adjacently but also fed on by *Megadelphax sordidula*. Photo O. Heikinheimo.

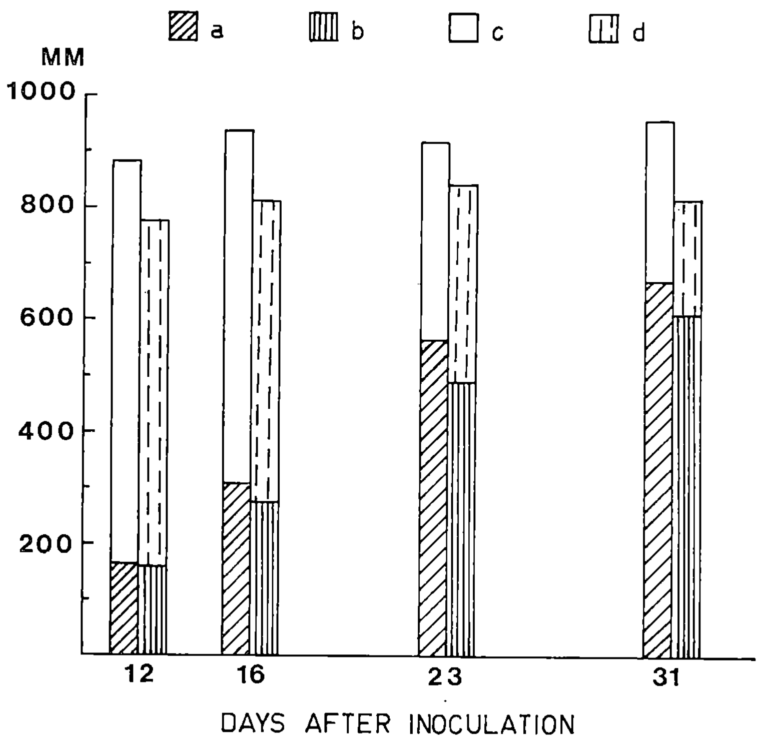

Fig. 4. Lengths of healthy oat plants compared with those of PGSV infected plants. Measurements made on different-aged plants sown on various dates. — a and c: healthy; b and d: PGSV-infected; a and b: measured July 17; c and d: measured from fully grown plants.

In the leaves of infected timothy test plants, the pale green stripes were more or less distinct, although the colour difference was somewhat less pronounced than in cereals (Fig. 2). In some leaves the pale area extended throughout the entire width of the blade. In such leaves there remained narrow streaks of dark green colour at the base of the leaf

Table 1. Charasteristics of PGSV infected oat plants compared with those of plants fed on by *Megadelphax sordidula* which remained healthy. Measurements made 1963. A total of 261 healthy and 111 PGSV infected oat plants were examined.

Characteristics measured	Means		Unbiased estimate of mean difference	F-value and its significance
	healthy	PGSV		
Total length of mature plant, mm	929	818	115	105.3***
No. of grains per spikelet on main shoot	1.5	1.1	0.4	75.0***
Grain yield per plant, mg	598	437	176	54.8***
% of light grains among total grains	21.2	36.9	−15.8	51.3***
No. of spikelets on main shoot	12.2	10.6	1.5	17.2***
Length of panicle stalk (tip of uppermost sheath to base of panicle), mm	124	107	17	12.5***
% of non-panicled shoots among total shoots	29.4	38.7	−7.8	7.4**
% of white spikelets among total spikelets	22.0	26.5	−3.6	6.0*
1000-grain weight, g	33.0	35.2	−1.3	4.7*
Time of panicle emergence; deviation of adjusted mean, days	0.39	0.80	−0.43	2.7
Total no. of spikelets on secondary shoots	5.85	5.59	0.58	0.4
Total no. of shoots	3.17	3.05	0.03	0.0

blades, such as often occur in the uppermost leaves of oats. In older timothy plants the pale green stripes were distinct only in some of the shoots. All the infected timothy plants grew much more weakly than healthy ones. This characteristic was very distinct in older plants.

Effect of injuries upon growth and yield

On July 17, 1963, the first length measurements of the oat plants were made simultaneously for the first four successive tests. In this manner parallel results were obtained from plants growing under the same conditions

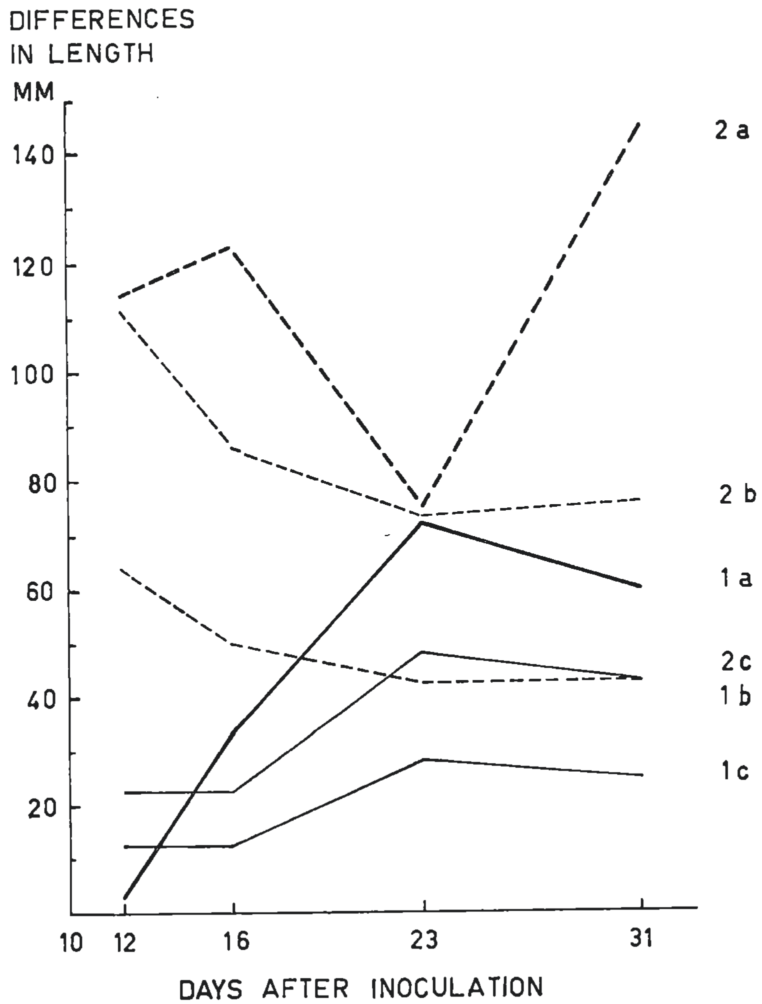

Fig. 5. Differences in length between healthy and PGSV-infected oat plants, the same material as in Fig. 4. — 1 a: Differences on July 17 due to the length of the time interval between inoculation and measurements. — 1 b: Statistically significant differences at the level of P = 0.1 %, and c: P = 5 %, respectively. — 2 a: Differences in the length of fully grown plants in successive tests. — 2 b: Statistically significant differences at the level of P = 0.1 %, and 2 c: P = 5 %, respectively.

Table 2. Differences in some characteristics between 17 check plants, 8 PGSV-infected, and 12 oat plants fed on by planthoppers, but remaining healthy.

Characteristic measured	Weighted means of measured data			Unbiased estimates of mean differences and their significance betweed	
	check	healthy	PGSV	check — healthy	healthy — PGSV
Total length of mature plant, mm	1031	968	840	38	140***
No. of grains per spikelet	1.6	1.3	1.2	0.10	0.14
Grain yield per plant, mg	851	653	472	97	216*
% of light grains among total grains	17.2	32.4	36.2	—7.2	—6.7

but of different ages. When comparisons were made between PGSV-infected oat plants and healthy plants fed on by virus-free *M. sordidula*, it could be seen that a statistically significant difference in length became evident after an incubation period of about 16 days (Figs 4 and 5). At this time the average difference was 33 mm. In full grown oat plants the determinations showed differences in length in the different test lots ranging from 75 to 140 mm.

Among the characteristics investigated, the differences between injured and healthy oat plants were most distinct — in addition to the length — in the number of grains per spikelet, in the grain yield, percentage of light grains, number of spikelets on the main shoot, and the length of the panicle stalk (Table 1). There were, on the other hand, only slight differences in the relative number of non-panicled shoots, percentage of white spikelets, and 1000-grain weight, the latter determination revealing slightly greater grain weights in injured than in healthy plants. Statistically significant differences were not found in the other characteristics investigated.

The grain yield of PGSV injured oat plants was on an average 27 % lower than that of healthy plants, and a similar difference was found in the number of grains per spikelet. The light grain content of infected plants was 74 % greater, and the number of spikelets per main shoot 13 % less than in healthy plants. Simultaneous emergence of the panicle in both groups shows that the difference in the length of the plants during growth was not due to a delay in development, but rather to a weakening in the vigour of the injured plants.

Some of the isolation cages contained check plants not fed on by planthoppers. The growth and yield of these plants was compared to that of both PGSV injured and healthy looking plants fed on by *M. sordidula*. This investigation concerned only those blocks (boxes) which contained oat plants belonging to all three of these groups (Table 2). Because of the limited size of the experimental material,

Table 3. Effect of PGSV on growth and yield of spring cereals. Insectary trial 1964. Measurements made at the same stage of maturity.

Companion crop	Means and 0.95 confidence limits						Unbiased estimate of mean difference	F-value and its significance
	No. of plants	Healthy		No. of plants	PGSV-infected			
Length of main shoot, mm								
Oats 'Tammi'	571	113.86	±0.73	198	101.39	±0.35	13.09	295.0***
Barley 'Pirkka'	58	95.6	±1.8	11	77.9	±5.0	18.41	54.5***
Spring wheat 'Apu'	99	97.5	±2.5	20	32.1	±8.6	65.0	318.6***
Grain yield of main shoot, mg								
Oats 'Tammi'	552	1744.5	±0.4	191	1170.7	±0.6	464.8	191.4***
Barley 'Pirkka'	58	1772	±83	11	961	±156	769	48.3***
Spring wheat 'Apu'	99	1043	±44	20	18	±27	1028	> 500***

Table 4. The effect of feeding by *Megadelphax sordidula* on the length of oat plants and their yield, 1964. No symptoms of OGSV were detected.

Test group	Average length of plants in mm	Difference	Average grain yield mg/plant	Difference
Male planthoppers	1089		1718	
		56.4 F = 5.4*		307 F = 13.8**
Control	1146		2025	
		55.2 F = 10.0**		224 F = 12.4**
Female planthoppers	1091		1801	

the differences between the test groups were statistically not as significant as in Table 1. When comparisons were made between all check plants (79 specimens), and the plants which had been fed on by *M. sordidula* females but remained healthy (20), an average difference in length of only 29 mm was found, which was not statistically significant.

In 1964, the effect of the PGSV-injury was studied in the same way as in 1963 (Table 3). The PGSV infection had caused an 11 % reduction in the length of oat plants, 8 % in barley, and 67 % in wheat. The reduction caused by PGSV in the grain yield was 33 % in oat, 45 % in barley, and 98 % in spring wheat. In all cases the reductions were highly significant.

There were distinctly less shoots and the shoots were markedly weaker on PGSV-infected timothy plants tested than on non-infected control plants.

The toxic injury of non-infective *M. sordidula* planthoppers manifested in the average length of mature plants, and in differences of grain yield between oat plants fed on by one planthopper for four to five days at one-leaf stage and control plants. A 5 % reduction in length growth, and 15 % reduction in grain yield were significant. No differences in injury caused by male and female planthoppers could be observed (Table 4).

Studies to determine the nature of the injuries of M. sordidula

Percentage of vectors of M. sordidula in the field material

The following table shows the numbers of *M. sordidula* planthoppers tested and the percentage vectors established in six planthopper populations collected in 1963 (cf. page 36):

Population No.	Grid 27° E	Locality	Age of timothy ley, years	No. of planthoppers tested	% of vectors
1	680:35	Pälkäne	1	1	0
2	699:23	Mustasaari	1	4	0
3	678:20	Rauma rural commune	old	11	9
4	675:20	Kalanti	1	11	45
5	675:20	Kalanti	old	37	41
6	675:20	Kalanti	old	48	38
		Total		112	35

In 1964, a total of 231 second to third stage planthopper nymphs collected from a third-year timothy ley at Kalanti (675: 20) in early spring, just after the snow had melted, were tested, 148 of them twice. The total percentage of PGSV-vectors was 17.6. Of these, 23 % caused symptoms in both the successive tests, 31 % in the first only, and 46 % in the second test.

17 % of young nymphs collected in Vantaa (668: 39), 1965, from a third year timothy ley in early spring proved to be PGSV vectors.

Effect of duration of inoculation

The planthoppers collected in 1964 which proved to be PGSV vectors after two successive tests, as described above, were transferred to oats for different lengths of time ranging from 20 minutes to two days. One oat plant was infected after six hours' inoculation feeding time, one after one day's feeding, while the others remained healthy. The PGSV symptoms of these two infected plants were as distinct as in other tests.

Transmission of PGSV

In the five successive tests made in 1963 with the six populations mentioned above, a total of 39 specimens from all the 112 proved to be PGSV-vectors (Table 5). Depending on how many successive tests could be made with each planthopper, the positive PGSV-infection (+) results were distributed as follows:

No. of tests	Total no. of + results 1	2	3	4	5	Total no. of vectors	No. of planthoppers tested	Vector %
1	2					2	10	20
2	0	2				2	10	20
3	2	5	3			10	21	48
4	0	2	0	1		3	11	28
5	4	7	7	2	6	22	60	37
Total						39	112	35

Table 5. PGSV infection transmitted by *Megadelphax sordidula* from different populations in successive tests with oats 1963. + = infected with PGSV, — = test plant remaining healthy. Further explanation, see text.

Population no.	Successive tests 1	2	3	4	5	Total +	Total −	% +
3	+	—	+	—	·	2	2	50
4	+	+	+	·	·			
	+	+	—	·	·			
	+	—	—	·	·			
	+	+	+	+	+			
	+	+	+	—	—	14	5	74
5	+	·	·	·	·			
	+	+	·	·	·			
	+	+	—	·	·			
	+	+	—	·	·			
	—	+	+	·	·			
	+	+	+	+	+			
	+	+	+	+	+			
	+	+	+	+	+			
	+	+	+	+	+			
	+	+	+	+	+			
	+	+	—	—	+			
	—	+	+	+	—			
	+	+	—	—	—			
	+	—	—	—	—			
	+	—	—	—	—	44	18	71
6	+	·	·	·	·			
	+	·	·	·	·			
	+	+	·	·	·			
	+	+	+	·	·			
	+	+	+	·	·			
	—	+	+	·	·			
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	+	+	—	—	+			
	+	+	+	—	—			
	+	—	+	+	—			
	+	—	—	—	+			
	+	+	—	—	—			
	—	+	—	—	—	44	25	64
Total + =	35	29	19	10	11 = 104			
— =	4	7	15	14	10 =		50	
Percentage mean of + =	90	81	56	42	52			68

The death of planthoppers during the course of tests was not due to less vigour in the vectors, since the relative number of positive infection results was as large with those specimens which lived during all the successive tests as with those which died soon after the first two or three tests. On the other hand, it is noteworthy that the percentage of positive results in Table 5 was considerably higher in the first two tests than in the following three.

In the transmission tests in early summer 1964 the grasses *Bromus inermis* Leyss., *Dactylis glomerata* L. *Festuca pratensis* Huds., *Festuca rubra* L., and *Lolium multiflorum* Lam. were used as test plants. Of these, only a single plant of *Bromus inermis* showed a paler green leaf colour differing from the other plants; no streaking, however, was visible. Such pale colouration could not be established definitely as a symptom of PGSV.

Infection of timothy (*Phleum pratense* L.)

Nine adult planthoppers were used in this trial, seven of which had been proved vectors in successive tests on oats. Of these latter, four produced PGSV-symptoms in timothy after a five-day inoculation feeding period. In the comparison group five planthopper adults which proved incapable of infecting the test plants were transferred to young timothy plants. None of these infected, and no differences in growth appeared when compared with uninoculated check plants. On the basis of visible symptoms, the PGSV infection in timothy persisted in the greenhouse for at least one year.

Third stage *M. sordidula* nymphs collected from third-year timothy fields, and placed on healthy timothy seedlings for some days, caused PGSV-infection symptoms on these plants. Some of these planthoppers proved later to be PGSV vectors.

Acquisition trials

Rearing *M. sordidula* under laboratory conditions was not successful. Consequently, in the acquisition trials planthopper nymphs were used which had been taken from the field; some of the planthoppers were PGSV-vectors. In 1963, adult planthoppers which had pre-

Table 6. Results of inoculations made after 10—11 days' acquisiton feeding by *Megadelphax sordidula* on PGSV-infected oat plants in successive tests. The planthoppers proved to be non-infective in two tests before the acquisition feeding. A = planthoppers fed on by healthy oats. B = acquisition feeding on PGSV oats. E = parasitized by *Elenchus tenuicornis* Kirby, + = test plant infected with PGSV, — = healthy test plant. Totally 16 (A), and 22 (B) planthoppers were tested.

Group	Vector	Successive tests, nos. 1	2	3	4	5	6	7	8	9
A	Male	+	+	+	—	—	—	—	—	—
	E	+	+	—	+	—	—	—	·	·
	Male	+	+	—	·	·	·	·	·	·
	Female	—	+	+	—	—	—	·	·	·
	Male	—	+	—	+	—	·	·	·	·
B	Female	+	—	+	+	+	+	+	+	—
	Female	+	+	+	—	+	—	—	·	·
	Male	+	+	+	+	·	·	·	·	·
	E	+	—	—	—	—	—	·	·	·
	E	—	—	—	—	+	+	—	·	·
	Female	—	—	—	—	+	+	·	·	·
	Female	—	—	—	—	—	+	·	·	·
	Female	—	—	—	—	—	+	+	·	·
	Female	—	—	—	—	—	+	·	·	·

viously been proved uninfected were placed for acquisition feeding on PGSV diseased oat plants. 19 planthoppers were tested on oats, some of them in 12 consecutive tests. It was found that not a single planthopper transmitted PGSV. In 1964, two acquisition trials were conducted, trial no. 1 in the spring with young nymphs, and no. 2 in June with 5th stage nymphs and adults which had not previously been tested for virus infection.

The planthoppers used in acquisition test no. 1 were kept on acquisition plants for 10 to 11 days, after which their ability to infect was determined in 9 successive tests on oats. The results (Tables 6 and 8) indicate that the vector percentage of planthoppers kept on healthy oats (check group A) was 31 %, and of leafhoppers feeding on PGSV infected oats (acquisition group B) 36 %. During the second to fourth tests the number of vectors did not rise. During the fifth and sixth tests, however, the number of vectors in group B doubled, while in the group A there was no increase, but instead, all the test results from the fifth onwards were negative. Among the planthoppers in at least the first five tests, 29 % were vectors in group A, and 47 % in group B. In the fifth to seventh tests, the corresponding vector percentages were 0 and 40 %. Of the test plants fed on by proved vectors the following percentages became infected during the consecutive tests (Table 8):

Treatment	Test no. 1	2	3	4	5	6	7	8	9
Without acquisition feed, A	60	100	40	50	0	0	0	0	0
Receiving acquisition feed, B	100	50	75	44	83	60	50	100	0

In the first four tests, an average of 60 % of the plants in group A fed on by vectors became infected, in the group B the figure was 67 %. In the fifth to ninth tests, the corresponding figures were 0 % in group A, and 67 % in group B. In group B there were five planthoppers (23 %) which had apparently no ability to infect in the first 4 tests but which caused infection in the fifth and sixth tests.

In acquisition trial no. 2, 1964, the fifth stage nymphs of *M. sordidula* were divided into two groups as before. Group A was kept for 12 days on healthy oat plants, group B on PGSV infected oat plants for the same period. Seven successive infection tests were made: 1 and 2 on oats, 3 on spring wheat, 4 on barley, and 5 to 7 on oats. Unfortunately, the oat plants in the fifth infection test were destroyed. The percentage vectors in groups A and B were 44 and 47, respectively, of the planthoppers tested (Tables 7 and 8). In the second and third tests, the number of vectors rose by only one in each group. In tests four to seven there was no vector increase in group A, while in group B there was an increase of two. Among those included in at least the first four tests there were 45 % vectors in group A and 48 % in the group B. On the basis of the fourth, sixth, and seventh tests, the vector percentage was 38 % for group A, and 78 % for group B.

The following percentages of test oat plants fed on by proved vectors became infected in the tests (Table 8):

Treatment	Test no. 1	2	3	4	6	7
Without acquisition feed, A	84	69	34	17	50	0
Receiving acquisition feed, B	76	81	34	47	67	29

A much greater proportion of the group B vectors infected the plants in the fourth to seventh tests than of the group A vectors.

In 1965, the young nymphs were divided into groups A, and B, as in 1964. Nymphs of group A were allowed to feed on healthy timothy plants, whereas nymphs of group B underwent acquisition feeding on PGSV in-

Table 7. Results of inoculation tests with *Megadelphax sordidula* PGSV-vectors after 12 days' acquisition feeding. Successive tests made on June 1964 with fifth-stage nymphs and adults collected from third-year timothy fields. Test plants: oats, nos 1, 2, 6, and 7, spring wheat, 3, and barley, 4. Other explanation as in Table 6.

Vector	Group A No. of successive tests 1	2	3	4	6	7
Female	+	+	+	+	+	+
Male	+	+	+	+	+	·
Female	+	+	+	—	+	·
Female	+	+	+	—	+	·
Male	+	+	+	—	·	·
Male	+	+	+	·	·	·
Female	+	+	+	·	·	·
Female	+	+	—	+	+	·
Female	+	+	—	+	+	·
Female	+	+	—	—	+	—
Female	+	+	—	—	+	·
Female	+	+	—	—	—	—
Male	+	+	—	—	·	·
Female	+	+	—	—	·	·
Female	+	+	—	—	·	·
Female	+	+	—	—	·	·
Female	+	+	—	—	·	·
Male	+	+	—	·	·	·
Male	+	+	·	·	·	·
Male	+	+	·	·	·	·
Female	+	+	·	·	·	·
Male	+	—	+	—	+	·
Female	+	—	+	—	—	+
Female	+	—	+	—	·	·
Female	+	—	—	—	·	·
Male	+	—	—	—	·	·
Female	+	—	—	—	·	·
Male	+	—	—	·	·	·
Male	+	—	—	·	·	·
Female	+	—	—	·	·	·
Male	+	—	·	·	·	·
Male	+	·	·	·	·	·
Female	+	·	·	·	·	·
Female	+	·	·	·	·	·
Male	+	·	·	·	·	·
Female	—	+	—	—	—	—
Female	—	+	—	—	—	·
Male	—	+	—	·	·	·
Male	—	+	—	·	·	·
Female	—	+	·	·	·	·
Male	—	—	+	—	—	·

Vector	Group B No. of successive tests 1	2	3	4	6	7
Male	+	+	+	+	+	·
Female	+	+	+	+	·	·
Female	+	+	+	+	·	·
Female	+	+	+	—	—	—
Female	+	+	+	·	·	·
Male	+	+	+	·	·	·
Female	+	+	+	·	·	·
Female	+	+	—	+	+	·
Female	+	+	—	+	—	·
Female	+	+	—	—	+	—
Female	+	+	—	—	+	—
Male	+	+	—	—	·	·
Male	+	+	—	—	·	·
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Male	+	—	—	·	·	·
Female	+	·	·	·	·	·
Male	—	+	+	+	+	—
Male	—	+	+	—	—	—
Male	—	+	+	—	·	·
Female	—	+	—	—	+	+
Female	—	+	—	·	·	·
Male	—	—	+	+	·	·
Female	—	—	—	+	+	·
Female	—	—	—	+	·	·
Female	—	—	—	—	+	+

fected timothy plants. The acquisition feeding time of both groups was nine days. The infection ability of nymphs was then tested in nine successive tests (Table 9). The ley grasses tested were: *Festuca pratensis* Huds., *Festuca rubra* L., *Bromus inermis* Leyss., *Dactylis glomerata* L., *Poa pratensis* L., *Lolium multiflorum* Lam., *Agropyron repens* (L.) Nevski, and *Phleum pratense* L., timothy. There were symptoms of PGSV on timothy only. 17 % of the planthoppers in the group A were vectors and 27 % in group B. Only two of the 36 planthoppers in group B proved to have acquired virus from the infected timothy plants. The test plants were infected by these planthoppers only in the fourth and fifth of the successive tests, 23 and 25 days from the beginning of acquisition feeding. In check group A, all planthopper vectors were already infective in the first or second of the successive tests. Altogether 73 % of the planthopper vectors infected at least two of the test plants.

In this acquisition test material there were also 21 nymphs of the planthopper species

Table 8. Feeding times, numbers of planthoppers, and test results after acquisition feeding. Explanations see Table 6.

Test no.	Inoculation feeding time days	Numbers of planthoppers tested A	Numbers of planthoppers tested B	No. of plants infected A	No. of plants infected B	Cumulative no. of vectors A	Cumulative no. of vectors B	No. of days from start of acquisition feeding
1. The test trial results presented in table 6								
1	4	16	22	3	4	3	4	14
2	5	16	19	5	2	5	4	19
3	5	16	16	2	3	5	4	24
4	4	14	15	2	2	5	4	28
5	5	14	15	0	5	5	7	33
6	8	11	11	0	5	5	9	39
7	6	8	8	0	2	5	9	46
8	5	3	1	0	1	5	9	54
9	4	3	1	0	0	5	9	63
2. The test trial results presented in table 7								
1	8	86	79	35	29	35	29	19
2	7	81	76	26	30	40	34	26
3	7	66	68	11	11	41	35	33
4	4	53	46	4	9	41	37	37
6	11	20	13	9	8	41	38	53
7	4	8	9	2	2	41	38	57

Table 9. Infection feeding times, test plants, and the numbers of planthoppers in successive tests of the planthopper groups A and B 1965. An aquisition feeding on PGSV-infected timothy. Other explanations as in Table 6. The ley grasses enumerated in the text.

Test no.	Inoculation feeding time, days	Test plants	Group A PGSV	Group A healthy	Group B PGSV	Group B healthy
1	5	Oats 'Tammi'	4	25	5	32
2	5	Oats 'Tammi'	3	26	7	29
3	4	Ley grasses	1	28	1	35
4	2	Spring wheat 'Apu'	0	7	1	5
		Spring wheat 'Svenno'	0	6	1	6
		Spring wheat 'Timantti'	0	6	0	9
		Spring wheat 'Selkirk'	0	5	1	6
		Spring wheat 'Norröna'	0	5	0	7
5	3	Oats 'Tammi'	1	26	6	29
6	3	Oats 'Tammi'	3	24		
		Ley grasses			0	23
7	4	Spring wheat 'Apu'	2	12	0	10
		Spring wheat 'Svenno'	0	13	0	10
8	2	Oats 'Tammi'	1	17		
		Spring wheat 'Apu'	0	7		
		Ley grasses			0	10
9	2	Oats 'Tammi'	1	23	1	9

Dicranotropis hamata (Bh.), 6 in the group A, and 15 in group B. One specimen from group B apparently acquired PGSV from the infected timothy plant, because its second ('Tammi' oat) and third ('Norröna' spring wheat) test plants were PGSV infected, showing typical and distinct symptoms.

Occurence of M. sordidula vectors and PGSV

On the basis of the materials collected for the trials in 1962—1965, PGSV infective *M. sordidula* were found in three localities (cf. p. 43). In these materials the percentage of in-

Table 10. Number of *Megadelphax sordidula* per 60 net sweeps in hayfields of different ages.

Age of ley, years	South Finland Total adults	Brachypters No.	%	Middle Finland Total adults	Brachypters No.	%	North Finland Total adults	Brachypters No.	%	Total Total adults	Brachypters No.	%
1	2.2	1.0	44.0	0.3	0.1	18.8	0.0	0.0	0.0	1.4	0.6	41.9
2	2.6	1.6	61.2	1.1	0.8	69.4	0.9	0.8	80.9	1.9	1.2	63.8
3	3.6	2.3	64.9	1.3	1.1	82.3	0.6	0.5	87.1	2.6	1.8	67.7
4	9.8	5.3	54.8	2.9	2.4	85.6	0.3	0.3	100.0	6.1	3.6	59.5
>4	5.4	3.4	62.3	2.1	1.9	91.3	5.5	2.1	38.5	4.4	2.5	56.5

fective planthoppers was high. Relatively speaking the proportions of vectors were equally large in the planthopper specimens collected from both first-year and third-year or older timothy fields. Among the nymphs collected in April the percentage of infected planthoppers was distinctly less than in June, e.g. in 1964: 18 % in April, and 44 % in June.

Specimens of *M. sordidula* which caused leaf striations in oats were collected by NUORTEVA (1962) at Bromarf (665: 27), South-west Finland.

According to Dr. Katri Bremer (oral communication), in timothy leys of different ages she found the same kind of symptoms as were produced by *M. sordidula* in our timothy infection trials. She suspected that it was a new virus disease, but the agent transmitting it was not found. The plants having pale green stripes in their leaves were weaker than normal plants. The symptoms were more pronounced in the spring and autumn. Such diseased plants were encountered by her in different locations in southern Finland, in the vicinity of Helsinki (667:38), along the west coast between Turku (671: 23) and Vaasa (700: 23), and in the region of Mikkeli (684: 51). We also discovered some timothy plants with symptoms similar to PGSV along the western coastal region between Turku and Vaasa, e.g. in Kalanti. Cereals with PGSV symptoms were found in the field on one occasion only in an oat field in Kalanti, and even there the virus infected oats were scarce although about 40—50 % of *M. sordidula* consisted of the vectors of PGSV.

On the bionomics of M. sordidula

M. sordidula is univoltine in Finland, and it hibernates as a nymph especially in leys, ditch banks, pastures, waste lands, and meadows. The adults emerge in June. More than half of the specimens emerging in leys are probably brachypters. Their proportion increases towards the north where the day is longer in summer, and the population density lower than in the south. In old leys the proportion of brachypters is also higher than in first-year leys (Table 10).

The brachypters usually stay in leys to reproduce, and only a few individuals move in the field layer to the edges of the cereal fields. The longest distance moved was found to be 25 m. On the basis of the material collected by netting apparatuses it seems that the macropters migrate in western Finland (63° N) between June 8 and July 18 (Fig. 6). Migration generally occurred only on days when the temperature was above average, i.e. when the maximum temperature for the day was at least 16° C. Migrating individuals descended mainly on spring cereals, but also on winter cereals, leys, and other vegetation.

M. sordidula prefers warm and dryish fields. Its abundance in leys on different soils was stated as follows:

Soil type	Adults/60 sweeps
Clay soils	4.06
Coarse mineral soils	2.63
Organic soils	1.32

The difference between clay soils and organic soils was statistically significant. As the leys aged, the density of *M. sordidula* increased up to the fourth-year but may have decreased

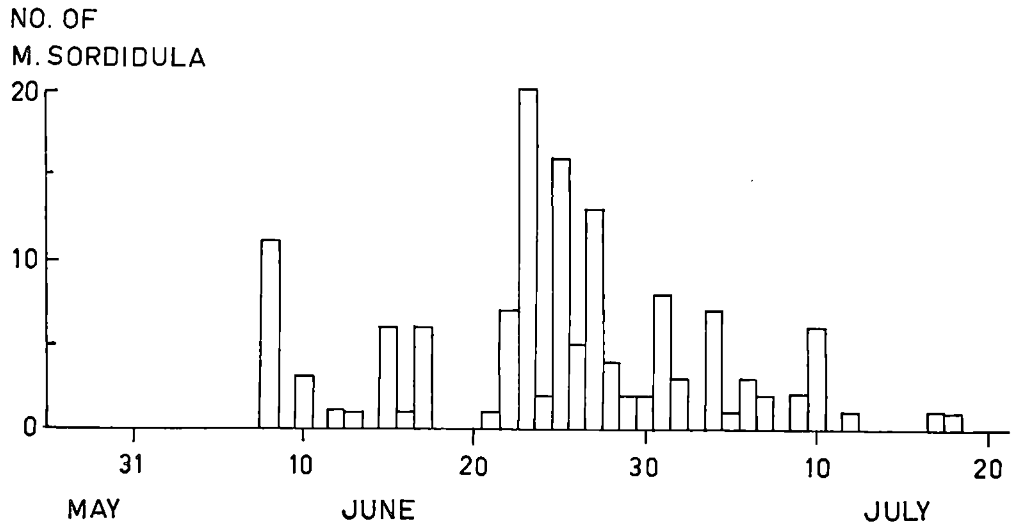

Fig. 6. Migration of macropterous *Megadelphax sordidula* in 1957—1964.

then (Table 10). This difference is statistically highly significant.

According to the netting samples taken at the turn of June and July, *M. sordidula* was fourth in abundance of the leafhoppers in leys, numbering 2 738 adults or about 4 % of adult leafhoppers. More abundant species were *Doliotettix pallens* (Zett.), *Diplocolenus abdominalis* (F.), and *Javesella pellucida* (F.). According to the material collected from oats at the turn of June and July, *M. sordidula* was fifth in abundance of the leafhopper species, accounting for 1 280 adults or 1.9 % of 68 932 adult leafhoppers. More abundant species were *Javesella pellucida*, *Macrosteles cristatus* (Rib.), *Doliotettix pallens*, and *Javesella obscurella* (Bh.). There were, however, great fluctuations in the abundance of *M. sordidula*. For instance, two- or threefold fluctuations in the density between different years were not exceptional. The density seemed to have been lowest in the years following cool summers, and greatest after warm summers. Also mortality during the winter was great and variable. For example, according to the suction samples caught in the field in autumn and spring average mortality during winter was 82 % but occasionally it could be as high as 90 %. The influence of natural enemies on the populations was also considerable (RAATIKAINEN 1961, 1970).

The abundance of *M. sordidula* on leys according to the samples collected at the turn of June and July is presented in Fig. 7. The material caught by sweep net at the turn of June and July shows the density of the species in oat fields (Fig. 8). These figures, 7 and 8, show that *M. sordidula* has spread to South and Central Finland, and its density is greatest in Southeast and South Finland.

Variation in spatial abundance is influenced by several factors mentioned previously. Furthermore, tilling the fields is a very essential factor. The species remains in leys during the whole ley phase which lasts a little longer than 2.4 years on the average. On the other hand, descendants of the specimens migrating to cereals are destroyed in the nymphal stage, mainly during autumn ploughing, and those that remain perish during spring soil preparation. Only when the spring cereal has been undersown with grass will the species survive for some 3.4 years. The proportion of spring cereals undersown with grass of the whole cereal area varies from one cultivation area to another and is greater in eastern Finland than it is in western Finland. This factor explains partly the great abundance of *M. sordidula* in eastern Finland.

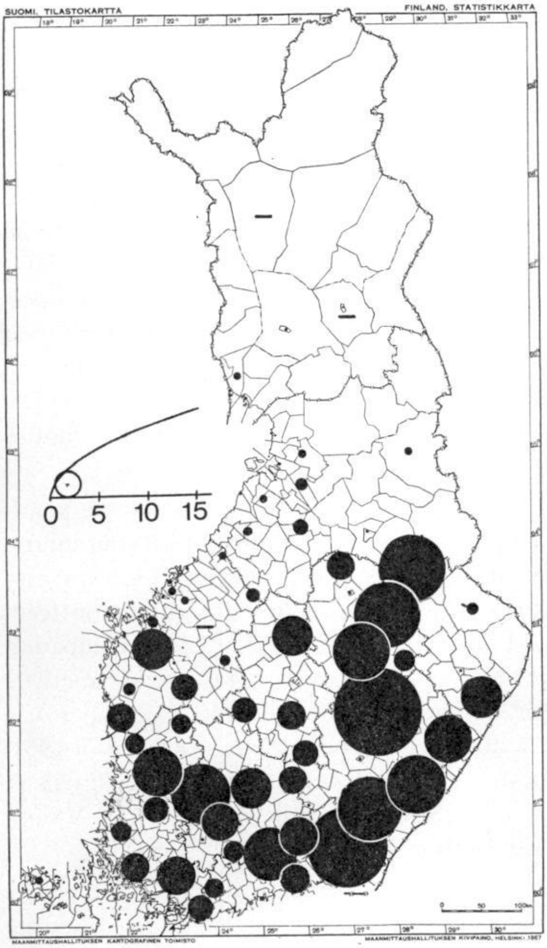

Fig. 7. Number *Megadelphax sordidula* per 60 sweeps in leys in 1966—1968.

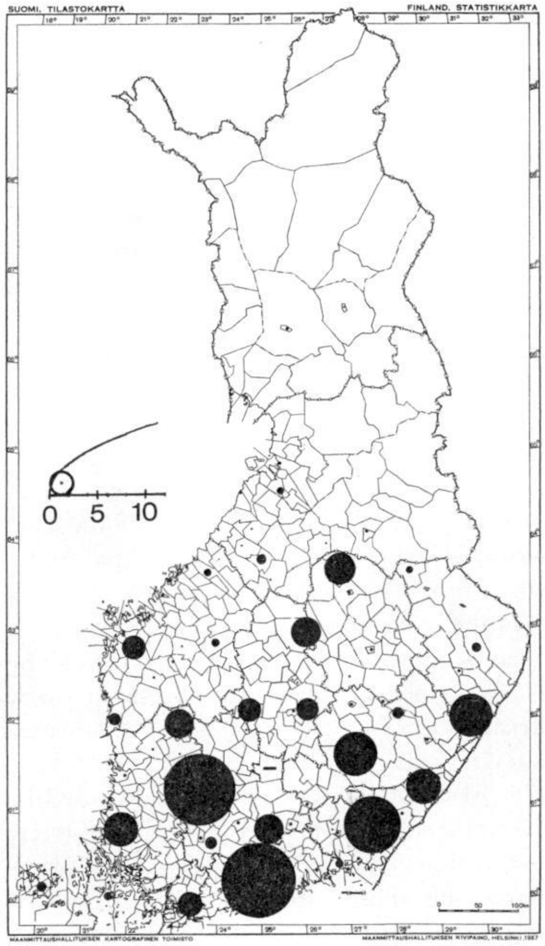

Fig. 8. Number of *Megadelphax sordidula* per 60 sweeps in oat fields in 1962—1964.

DISCUSSION

Toxic injuries of M. sordidula

Toxic symptoms of gramineous plants sucked by planthoppers is manifested in decreasing elongation growth and on increasing number of light-weight grains (NUORTEVA 1962) and, consequently, in the grain yield. No toxic injuries with chlorotic or yellow striations caused by planthoppers are known from gramineous plants. These are typical to most virus diseases on cereals and grasses.

According to the limited experimental material available, the results of the toxic effect of feeding by *M. sordidula* show, that the species may have a mild influence in the elongating growth and yield of plants (Tables 2 and 4). The females did not differ in toxic effect from the males.

The nature of Phleum green stripe disease agent

Typical for many gramineous plant viruses transmitted by leafhoppers and planthoppers are the yellowish streaks and striations of varying length and width on leaf blades and sheaths. In this respect PGSV closely resembles EWSMV. However, in the latter the streaks are yellow, pale yellowish or tinged with red; no evidence of green is present. If these striations appear in seedlings at the 4—5-leaf stage, the plants cease growing completely and die long before maturity. The symptoms of PGSV, on the other hand, are more mild on oats and barley: the size of the stripes does not change and the plants do not stop growing at an early stage or die. On spring wheat PGSV symptoms resemble most those of EWSMV, but the plants do not die prematurely. When grains develop on wheat, they are not shriveled as in EWSMV, but wrinkled, and growth is checked. 'Apu' spring wheat proved to be more susceptible to PGSV than the other wheat cultivars tested.

Some confusion is possible in distinguishing PGSV symptoms on timothy from the toxic striations caused by the aphid *Cuernavaca muehlei* (Börner) (FRÖHLICH 1959/60). However, the distinct yellow striations caused by the aphid on timothy leaves and shoots are always limited to only such parts of the plants where the aphids are sucking, whereas the pale green stripes of PGSV are systemic, developing in several shoots and leaves of timothy, and the whole plants are weak in growth.

The investigations carried out to determine the nature of injuries produced by *M. sordidula* have shown that a disease agent most resembling a virus is involved. In our trials certain facts appeared which cannot be explained other than by stating that *M. sordidula* can act as a virus vector:

1. The symptoms of the injury are most likely some known planthopper transmitted gramineous viruses. The symptoms are systemic occurring as readily in the lateral shoots as in the main shoot which was inoculated.

2. The intensity of symptoms was relatively constant, when infected at the same developmental stage of a plant, quite independently of the length of feeding time. Six hours feeding time was sufficient to produce all the symptoms typical of PGSV.

3. The length of incubation time for PGSV in plants (10 to 40 days, on average 18) is typical of persistent planthopperborne viruses.

4. A great number of the planthoppers in a population caused no PGSV symptoms at all, but of the infective planthoppers 70—82 % transmitted the disease more than once, and as many as 14—23 % caused injury in at least four successive test plants. If the infective ability had occured at random in the entire leafhopper population, the above figures would have been much smaller.

5. In acquisition feeding trials some planthoppers originally incapable of causing injury, became capable of producing PGSV-symptoms only after receiving an acquisition feed, and this was manifested after an incubation period of 26—37 days. This is characteristic for persistent and circulative leafhopper and planthopper borne viruses (IKÄHEIMO 1961, IKÄHEIMO and RAATIKAINEN 1961, PRŮŠA et al. 1959, SLYKHUIS and WATSON 1958, VACKE and PRŮŠA 1961).

The gradual decrease in infective ability manifested in the successive tests may indicate that the concentration of the disease agent in planthoppers decreases if there is no new acquisition from infected plants, and that it cannot perhaps multiply in the vector (SLYKHUIS 1963) but only in cereals and timothy. In the latter case, the symptoms are visible at least one year, and the vector percentage of *M. sordidula* rises during nymphal development in the spring.

PGSV does not seem to be pathogenic to its vector.

Dicranotropis hamata, one specimen of which proved to be a PGSV vector, is known to be able to transmit OSDV (IKÄHEIMO and RAATIKAINEN 1963, LINDSTEN 1961 b), and CTDA (LINDSTEN et al. 1973), also. Because of the very limited material available, this species needs further studies to establish its ability transmit PGSV.

The significance of PGSV and M. sordidula

The name of this new virus-like disease agent, the *Phleum* green stripe virus, was chosen to indicate the importance of timothy as a source of infection. Although detailed studies on the transferrence of the virus-like agent from the timothy by means of *M. sordidula* are lacking, the observations obtained reveal the significant position of timothy in the virus cycle. The rising of the vector percentage during the nymphal period of the development of the vector on timothy, and the high vector percentage in June, just before migration time for *M. sordidula* in both young and old timothy leys indicates timothy to be the most important source of PGSV infection.

The yield loss in infected timothy plants was very distinct, although it had not been measured. The decrease in grain yield of infected oats and barley were statistically highly significant, and the infection of wheat may lead to complete failure of crops. However, the numbers of infected plants in the fields have been small. This is due to the life cycle and low population density of *M. sordidula.*

PGSV hibernates both in the nymphs of *M. sordidula* and in timothy. The virus is transmitted into timothy leys and spring cereals mainly by macropterous migrating planthoppers. The significance of *M. sordidula* as a vector of PGSV is probably greatest in old timothy leys in southern Finland, where the species occurs most commonly and where virus infected timothy plants are most often found. In such places the virus may be significant as a factor causing crop losses.

Considering the facts that the density of the macropterous individuals of *M. sordidula* is rather low and the migration period occurs later than that of the vectors of OSDV and EWSMV (*Javesella pellucida, J. obscurella,* and *Dicranotropis hamata*), it seems that PGSV cannot cause great damage in the form of crop losses.

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MS received 12 January 1976

Osmo Heikinheimo
Agricultural Research Centre
Institute of Pest Investigation
SF-01300 Vantaa 30, Finland

Mikko Raatikainen[1]
Agricultural Research Centre
Institute of Pest Investigation
SF-01300 Vantaa 30, Finland
[1] Present adress:
University of Jyväskylä
Institute of Biology
SF-40100 Jyväskylä 10, Finland

SELOSTUS

Kyyttökaskas, Megadelphax sordidula (Stål) (Hom., Delphacidae) timotein viherjuovaviruksen (PGSV) vektorina

OSMO HEIKINHEIMO
Maatalouden tutkimuskeskus

MIKKO RAATIKAINEN
Maatalouden tutkimuskeskus[1]

Kyyttökaskas, *Megadelphax sordidula* (Stål)) todettiin entuudestaan tuntemattoman viruksen kaltaisen taudinaiheuttajan, timotein viherjuovaviruksen (*Phleum* green stripe virus) vektoriksi. Se aiheutti kaurassa, ohrassa ja timoteissa vaalean vihreitä juovia ja viiruja, jotka usein ulottuivat lehtilavan päästä päähän. Tauti aikaansai myös kasvien kasvun ja sadon heikkenemistä. Kevätvehnälajikkeessa 'Apu' vioitukset olivat samankaltaisia, mutta huomattavasti ankarampia. Sen kasvu pysähtyi tavallisesti kokonaan ja kasvupiste tuhoutui jo aikaisessa vaiheessa. Juovat ja viirut vehnässä olivat väriltään keltaisia — vaalean vihreitä. Muissa vehnälajikkeissa vioitussymptomit eivät olleet yhtä ankaria. Vehnässä symptomit muistuttivat paljon vehnän juovamosaiikkiviruksen (EWSMV) symptomeja, mutta selviä eroja on todettu. PGSV alensi vioittuneiden kaurojen satoa 27—33 %, ohran satoa 46 % ja kevätvehnän ('Apu') 98 %. Saastuneet timoteiskasvit kasvoivat paljon heikommin kuin vastaavat terveet. Symptomit säilyivät timoteissa ainakin vuoden ajan.

Timotein viherjuovaviruksen inkubaatioaika kaskaissa oli 26—37 vrk. ja kasveissa keskimäärin 18 vrk. Lyhin infektoitumiseen johtanut imentäaika oli 6 tuntia.

Timotei on ilmeisesti tärkein PGSV:n tartuntalähde. Vioitussymptomeja on todettu eri-ikäisistä timoteipelloista Etelä- ja Lounais-Suomesta. Timotein iästä riippumattomasti vektorien prosentuaalinen osuus *M. sordidula* -kaskaista voi nousta yli 40 %. Vaikka sairastuneissa kasveissa sadon aleneminen on huomattavaa, saattaa timotein viherjuovaviruksella ja kyyttökaskaalla olla merkitystä vain paikallisesti timotein rehusadon alentajana. Tämä johtuu paitsi kaskaan alhaisesta populaatiotiheydestä, myös pitkäsiipisten kaskaiden melko alhaisesta suhteellisesta määrästä sekä myöhäisestä lentoajasta.

[1] Nyk. osoite: Jyväskylän Yliopisto, Biologian laitos.

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Seria ANIMALIA NOCENTIA N. 78 — Sarja TUHOELÄIMET N:o 78

PRELIMINARY STUDIES ON FLOWER VISITORS TO AND POTENTIAL POLLINATORS OF THE CLOUDBERRY (RUBUS CHAMAEMORUS L.) IN SUBARCTIC LAPLAND

HEIKKI HIPPA and SEPPO KOPONEN

HIPPA, H. & KOPONEN, S. 1976. **Preliminary studies on flower visitors to and potential pollinators of the cloudberry (Rubus chamaemorus L.) in subarctic Lapland.** Ann. Agric. Fenn. 15: 56—65. (Univ. Turku, Dept. Zool., SF-20500 Turku 50, Finland.)

In 1974—75 insects visiting cloudberry flowers were studied in Utsjoki Lapland, Finland. Besides the abundance of the different groups on the flowers, attempts were made to measure their pollen carrying capacity and fidelity to the cloudberry by means of pollen analysis.

The most abundant insects staying for longer periods on the flowers were thrips and staphylinid beetles. Depending on the locality, thrips were found in quantities of 0.81—9.43 ind./male and 0.18—5.00 ind./female flower. Respective values for staphylinids were 0.46—2.72 and 0.06—0.08. The role played by thrips and staphylinids in pollinating cloudberry seems to be insignificant.

Of the other insects the Diptera species were the most numerous, especially anthomyid and empidid flies. Of these two groups anthomyid flies were the most abundant at all study sites in 1974, but in 1995 empidids outnumbered them, especially on female flowers. Because of their abundance and pollen carrying capacity, anthomyids may play an essential role in pollinating the cloudberry.

Bumblebees were infrequent visitors to cloudberry and after the Ericaceae plants started flowering they shifted to them. Pollen carrying capacity and the proportion of cloudberry pollen being carried was, however, ample on the few individuals captured (which were taken, however, from male flowers).

Index words: *Rubus chamaemorus*, flower visitors, pollination.

INTRODUCTION

Because of the great economic importance of the cloudberry in northern Fennoscandia, methods of improving and ensuring its natural yield are being actively studied. Cultivation experiments have also been carried out, in Norway and Finland especially (see e.g. MÄKINEN and OIKARINEN 1974).

A typical feature under both natural and experimental conditions is the uncertainty of the yield. This is most often said to be attributale to bad weather, especially frost, during the period of flowering and fructification (cf. JAAKKOLA and OIKARINEN 1972). Unfortunately, only scant information is available on cloudberry pollinators and on how their activities are affected by weather conditions (see SANDVED 1958).

Insect fauna visiting cloudberry flowers has been investigated by only a few authors. Early notes were made by SCOTT ELLIOT (1896) and KNUTH (1898), who reported from the British Isles on empidid and muscid flies and from Norway on bumblebees. DALLMAN (1932) found species of Diptera, Hymenoptera and Coleoptera; empidid flies dominated in his material. SANDVED (1958) reported empidid and syrphid flies as well as bumblebees from northern Norway and suggested that the latter were the most important pollinators. TAYLOR (1971) mentioned the empidid and anthomyid flies as two groups of common visitors to cloudberry flowers in England.

The aim of the present work is to give preliminary information on the pollination biology of cloudberry in the northernmost part of Lapland, which is an important area for cloudberry production.

STUDY AREA, METHODS, AND MATERIAL

The study area is situated around the Kevo Subarctic Research Station in Utsjoki, Lapland, approximately between 69° 45'—69° 50' N and 26° 50'—27° 10' E. For general characteristics of the area, see e.g. KALLIO (1964).

Flower visitors were collected and studied in three localities: 1) Kevonniemi, a small bog in pine and birch forests, about 100 m above sea level; 2) Puksalskaidi, a bog with a pond, surrounded by birch forest and some isolated pine stands, about 200 m above sea level; 3) Skallovaara, a wide bog area at the upper limit of the birch zone, about 280 m above sea level. Some small samples were also taken from a small bog with a pond at Shirrajärvi, about 200 m above sea level.

The field work was done in 1974 and 1975, during the last half of June and the beginning of July. In 1975 unfavourable weather conditions greatly disrupted the work and flowering began about a week later than in 1974. In both years the cloudberry began flowering first at Puksalskaidi, then at Kevonniemi and last at Skallovaara, the time lag between Puksalskaidi and Skallovaara being about one week.

Insects visiting the flowers were collected by netting. The specimens caught were enclosed in small glass tubes and killed with chloroform. Because female flowers were less abundant than male flowers at the study sites, attempts were made to catch all insects visiting female flowers. From the male flowers only some samples were taken. The material caught by netting constituted about 1450 specimens.

Thrips and staphylinid beetles were studied by taking random samples of flowers, on which the insects were checked in the laboratory by a stereo microscope. Altogether 285 flowers were checked. On these there were about 1000 insects.

The number of pollen grains carried by different flower visitors was counted from the specimens preserved as described above. The amount of pollen lost in catching and handling the living specimen is not known. The pollen was identified using glycerine-methylene blue slides. Most attention was paid to the pollen on insects collected from female flowers. As yet, only part of the material has been analyzed.

To estimate the importance of small-sized insects in pollination, excluders with different mesh sizes were used. Areas covered varied from 1/16—2 m^2.

Flower stayers

The collective term "flower stayers" is used here for thrips (*Thysanoptera*) and a staphylinid beetle (*Anthobium lapponicum*). These two groups differ from the other insects dealt with in this paper in that they seem to stay in a flower for long periods. Due to their behaviour and their small size the method of collecting these insects differed from that applied for the other groups.

The numbers of thrips per flower are shown in Table 1. There is a notable difference between the localities studied as well as between the sex of flowers. Thrips collected from male flowers were often carrying pollen grains, usually 1—4 per animal. On those collected from female flowers only occasional pollen grains were found. These may have derived from the same flowers, which had already been pollinated.

Table 1. The mean numbers of thrips (Thysanoptera spp.) per cloudberry flower (with S.E.) at Kevo, 1974.

	Date	Male flowers Ind./flower	n	Female flowers ind./flower	n
Kevonniemi	June 19	9.43 ± 0.91	51	5.00 ± 0.53	40
Shirrajärvi	June 24	0.81 ± 0.17	64	0.18 ± 0.06	50

The numbers of staphylinid beetles per flower are shown in Table 2. Like thrips, the beetles seem to faour male flowers, but the difference in their numbers between the study localities is less marked. The specimens collected from male flowers frequently carried pollen, but usually less than 10 grains per individual. On about 10 specimens studied from female flowers no pollen was found. The staphylinids in question are known inhabitants of cloudberry flowers (see e.g. Brundin 1934, Strand 1946). They eat pollen and stamens, and are often seen to copulate on flowers (see also Mäkinen and Oikarinen 1974). The beetles are sometimes already found inside the buds of flowers.

Table 2. The mean numbers of *Anthobium lapponicum* (Col., Staphylinidae) per cloudberry flower at Kevo, 1974.

	Date	Male flowers Ind./flower	n	Female flowers Ind./flower	n
Kevonniemi	June 19	1.18 ± 0.25	51	0.08 ± 0.06	40
Shirrajärvi	June 24	0.46 ± 0.09	64	0.06 ± 0.04	50
Puksalskaidi	June 14	0.92	25		
Puksalskaidi	June 14	2.72	25		
Skallovaara	June 18	2.30	30		

Flower visitors

The term "flower visitor" means here those arthropods which usually visit flowers rather briefly and which usually actively fly or run from one flower to another. The methods of capturing these insects also differed from that used for the flower stayers.

Sandved's (1958) data from the Lofoten Islands on cloudberry pollinators has been cited by many authors (e.g. Østgård 1964, Paulsen 1972, Lohi 1974, Mäkinen and Oikarinen 1974) as valid for northern Fennoscandia, and bumblebees are commonly mentioned as the most important cloudberry pollinators in this area.

Composition of material in 1974—75

Members of the following groups of Arthropoda, in the order of relative abundance, were collected from cloudberry flowers: *Anthomyiidae*, *Empididae*, *Syrphidae*, *Sciaridae*, *Cordyluridae*, *Cecidomyiidae*, *Phoridae*, *Chloropidae*, *Helomyzidae*, *Ceratopogonidae*, *Culicidae*, *Calliphoridae*, and *Simuliidae* (*Dipt.*); *Formicidae*, *Apidae*, *Chalcididae*, *Vespidae*, and *Tenthredinidae* (*Hym*); *Chrysomelidae* and *Helodidae* (*Col.*); *Tortricidae* and *Glyphipterygidae* (*Lep.*); *Thomisidae* and *Lycosidae* (*Aran.*); *Auchenorrhyncha* (*Hom.*).

The numbers and percentages of different insect groups in the material are shown in Tables 3—5. In both years and in all localities the Diptera species constituted the dominant groups of flower visitors. In the 1974 material the dominance of anthomyid flies within Diptera is distinct: 82.8 %—98.2 % on male and 80.4 %—100.0 % on female flowers. In the whole material of flower visitors, too, they account for 49.0 %—97.5 % on male and 72.0 %—96.6 % on female flowers in 1974. In the 1975 material the abundace of empidid flies is conspicuous, especially on female flowers where they outnumber anthomyids both in Skallovaara and Puksalskaidi, accounting for 57.6 %—69.2 % of the total number of female flower visitors. There are rather distinct local differences, especially in the abundance of anthomyid flies whose proportion is greatest on the harsh Skallovaara bog. Of the other Diptera syrphids are the only ones worth mentioning. Their proportion is greatest (7.8 % on male and 15.4 % on female flowers) in the 1974 material from the lowly situated Kevonniemi bog. In the materials from Skallovaara and Puksalskaidi there is a marked reversal of the difference between the two years.

Notable quantities of other insects were collected only on the Puksalskaidi bog, around a small pond. Apids (bumblebees and solitary bees) were found only in 1974 and mainly on male flowers (5.1 %). Also chrysomelid beetles appear only in the material for the year 1974, when they formed the next most abundant group (24.0 % on male and 12.0 % on female flowers) after anthomyid flies. Among these chrysomelids there were many specimens of *Galerucella "nymphaeae* L.", which is a serious cloudberry pest (see HIPPA and KOPONEN 1975). Ants were found in both years, but they were more abundant in 1975 than in 1974 (8.0 % and 16.7 % on female flowers).

The marked difference between the material in the years 1974 and 1975 may at least partly be due to the colder weather during the flowering period in 1975. E.g. the mean temperature at Kevo during the period June 10—July 10 was 13.0° C in 1974, but only 8.7° C in 1975. In the case of empidid flies, the abundance of bigger anthomyids in 1974 may have somewhat reduced their chances of being discovered.

Table 3. Numbers of arthropods collected from cloudberry flowers at Skallovaara bog, 1974—75 (Thysanoptera spp. and *Anthobium lapponicum* excluded).

	Male flowers				Female flowers			
	1974		1975		1974		1975	
	Ind.	%	Ind.	%	Ind.	%	Ind.	%
Anthomyiidae	544	97.5	217	72.3	28	96.6	11	33.3
Empididae	2	0.4	57	19.0	0	0	19	57.6
Syrphidae	1	0.2	18	6.0	0	0	1	3.0
Other Diptera	7	1.3	5	1.7	0	0	1	3.0
Apidae	0	0	1	0.3	0	0	1	3.0
Formicidae	0	0	2	0.7	0	0	0	0
Chrysomelidae	2	0.4	0	0	0	0	0	0
Other Arthropoda	2	0.4	0	0	1	3.4	0	0
Total	558	100	300	100	29	100	33	100

Table 4. Numbers of arthropods collected from cloudberry flowers at Puksalskaidi bog, 1974—75 (Thysanoptera spp. and *Anthobium lapponicum* excluded).

	Male flowers 1974		Female flowers 1974		Female flowers 1975	
	Ind.	%	Ind.	%	Ind.	%
Anthomyiidae	96	49.0	18	72.0	4	5.1
Empididae	7	3.6	0	0	54	69.2
Syrphidae	12	6.1	0	0	0	0
Other Diptera	1	0.5	1	4.0	7	9.0
Apidae	10	5.1	0	0	0	0
Formicidae	18	9.2	2	8.0	13	16.7
Chrysomelidae	47	24.0	3	12.0	0	0
Other Arthropoda	5	2.6	1	4.0	0	0
Total	196	100	25	100	78	100

Table 5. Numbers of arthropods collected from cloudberry flowers at Kevonniemi bog, 1974 (Thysanoptera spp. and *Anthobium lapponicum* excluded).

	Male flowers		Female flowers	
	Ind.	%	Ind.	%
Anthomyiidae	114	88.4	82	78.8
Empididae	0	0	4	3.8
Syrphidae	10	7.8	16	15.4
Other Diptera	0	0	0	0
Apidae	1	0.8	1	1.0
Formicidae	0	0	1	1.0
Chrysomelidae	1	0.8	0	0
Other Arthropoda	3	2.3	0	0
Total	129	100	104	100

Frequency and duration of visits

The numbers of insect visits per single cloudberry flower were counted during warm sunny weather on Puksalskaidi bog in 1974 (Table 6). Mean numbers of visits by insects, mainly anthomyid flies, were similar for male and female flowers (4.0 and 3.8 visits/flower/hour, respectively). Because individual flowers are open for two or three days (Lohi 1974), the total number of visits per flower under good weather conditions can be very high.

Table 6. The frequency of visits per cloudberry flower by insects (mainly anthomyid flies) at Puksalskaidi bog, June 15—17, 1974.

	Male flowers Visits/flower/h	n	Female flowers Visits/flower/h	n
I	2.3	18	1.6	15
II	5.0	26	5.3	4
III	4.6	10	4.6	14
Mean	4.0		3.8	

The duration of visits by insects, mainly anthomyid flies, was also measured (Table 7). On male flowers 50 % of the flies visited very briefly (1—2 seconds), 40 % stayed 5—30 seconds and the rest longer. The respective percentages for female flowers were 32 % and 59 %.

The duration of visits by bumblebees was measured during the first week of cloudberry flowering in 1974. The mean time per flower, including the time required for flying to an other flower, was determined as 4.5 seconds (n = 23). However, bumblebees and other apids are rare and they were observed to shift their visits to the Ericaceae species when these more attractive plants started flowering.

Table 7. The duration of visits by insects to cloudberry flowers at Puksalskaidi bog, June 15, 1974.

	Duration of visit					
	Male flowers (n = 18)			Female flowers (n = 15)		
	Rapid	5–30 sec	> 30 sec	Rapid	5–30 sec	> 30 sec
Anthomyiidae	18	14	4	7	13	3
Syrphidae	2	2	0	0	0	0
Bombus spp.	0	1	0	0	1	0
Total	20	17	4	7	14	3

Pollen carrying capacity and pollen analysis

The number of pollen grains on the flies collected from female flowers and the percentage cloudberry pollen are shown in Tables 8 and 9 respectively. In the anthomyid material all specimens studied carried some pollen and 89 % carried cloudberry pollen. Of these 89 %, nearly half (44 %) carried ± pure cloudberry pollen (90—100 % of all pollen grains). The bulk of pollen grains on anthomyids was found on the thorax.

Table 8. Approximate number of cloudberry pollen grains and total number of pollen grains on insects collected from female cloudberry flowers at Kevo, 1974—75.

	Total number of pollen grains				Number of cloudberry pollen grains				
	< 10	10–25	30–100	> 100	< 10	10–25	30–100	> 100	n
Anthomyiidae									
Skallovaara	5	12	2	3	10	12	0	0	22
Puksalskaidi	1	1	3	2	1	1	3	2	7
Kevonniemi	0	2	5	0	1	3 3	3	0	7
Total	6	15	10	5	12	16	6	2	36
Empididae									
Puksalskaidi	9	2	1	0	10	1	1	0	12
Syrphidae									
Kevonniemi	1	0	0	2	3	0	0	0	3

Table 9. Approximate percentages of cloudberry pollen grains of total number of pollen grains on insects at Kevo. Flies collected from female cloudberry flowers and apids from male flowers.

	Percentages of cloudberry pollen grains						
	0	<10	15–30	35–60	65–85	90–100	n
Anthomyiidae							
Skallovaara	3	3	4	4	2	6	22
Puksalskaidi	1	0	1	1	0	4	7
Kevonniemi	0	0	0	1	0	6	7
Total	4	3	5	6	2	16	36
Empididae							
Puksalskaidi	2	0	0	1	2	5	10
Syrphidae							
Kevonniemi	3	0	0	0	0	0	3
Bombus spp.							
Puksalskaidi	1	0	1	1	2	1	6

The number of cloudberry pollen grains was low (Table 8). About 33 % of the anthomyids carried less than 10 grains, and it is possible that some of these flies had got pollen from the female flowers already pollinated. Only 22 % of the anthomyids had considerable amounts of pollen (over 30 grains). Variations between the localities are clear; especially on Skallovaara bog pollen quantities are low, but on the other hand in this area anthomyids seemed to be almost the only visitors to flowers in 1974.

Most of the empidids studied (small-sized species) carried pollen grains. Although the total number was usually low, the percentage of cloudberry pollen was large. On the few syrphids studied no cloudberry pollen was found.

No bumblebee specimens were caught on female flowers. To estimate their pollinating capacity, six individuals from male flowers from Puksalskaidi bog were checked (Table 10). The quantities of pollen on these was very high, the total mean being about 1500 pollen grains and that of cloudberry pollens about 900. The bulk of the pollen was spread on the hairs of legs. Only one of the six specimens had pollen (Ericaceae) in baskets.

Table 10. Approximate number of pollen grains on six individuals of *Bombus* spp. collected from male cloudberry flowers on Puksalskaidi bog, June 14, 1974.

Number of pollen grains	Number of cloudberry pollen grains	Other abundant pollens
1000	800	Ericaceae
1000	600	Salix
1000	950	—
300	100	Salix
4000	3000	Salix
2000	0	Ericaceae

Insect excluders

The results with insect excluders in the two study sites at Skallovaara are shown in Table 11.

At site a, where only female plants were covered, no berries appeared. At this site the control sample also gave a very low percentage of fertilized flowers. At site b some berries developed under two excluders with a mesh size of about 1.5 mm covering only female flowers. Under three excluders covering male flowers also, berries appeared only in one case. In both cases the proportion of fertilized flowers (6—8 %) was, however, very low, compared with the control sample (54 %). The high percentage of unfertilized flowers or the lack of berries may be due, at least partly, to cold weather with possible frosts during the flowering period.

Table 11. Effect of excluders on cloudberry pollination at Skallovaara bog, 1975.

Site a

	Control		Mesh size 2 mm		1.5 mm		0.5 mm		0.5 mm	
Unfertilized female flowers	140	80.5 %	22	100.0 %	58	100.0 %	2	100.0 %	8	100.0 %
Fertilized female flowers	34	19.5	0	0	0	0	0	0	0	0
Male flowers in excluders			0		0		0		0	

Site b

	Control		Mesh size 2 mm		1.5 mm		1 mm		0.5 mm		Closed	
Unfertilized female flowers	40	46.0 %	24	92.3 %	67	94.4 %	24	100.0 %	14	100.0 %	4	100.0 %
Fertilized female flowers	47	54.0	2	7.7	4	5.6	0	0	0	0	0	0
Male flowers in excluders			0		13		5		0		1	

DISCUSSION

According to the results of KEVAN (1970) in the high arctic Canada the white flower colour seems to be unattractive to insects. Good insect flowers also had a special scent. These facts may explain our observation that bumblebees, and to a lesser extent syrphids, too, change from cloudberry to the more heavily scented and/or colourful species of Ericaceae when they start flowering.

KEVAN (1970) suggested that many insects, especially flies, stay in flowers for warmth. In those flowers, the structure of which is a "parabolic reflector" as in cloudberry, the body temperature of the insects in the sunshine may rise many degrees.

Different opinions on the importance of insect groups for pollinating flowers under arctic and subarctic conditions have been expressed (e.g. PANFILOV et al. 1960, MCALPINE 1965, KEVAN 1970, 1972).

Bumblebees have often been mentioned as the most important pollinators in northern areas. SANDVED (1958) and MÄKINEN and OIKARINEN (1974) regarded bumblebees as the most important cloudberry pollinators in northern Fennoscandia. According to our material the pollen carrying capacity of these insects is very high and their visits are very rapid. However, bumblebees seem to prefer male flowers and are not numerous enough, even at the beginning of the flowering period when there is not yet any competition from Ericaceae plants, to be responsible for the major part of pollination. The greater abundance of bumblebees on cloudberry flowers during early flowering may be connected with the better yield of the earlier flowers compared with the later ones (see MÄKINEN and OIKARINEN 1974).

Recently, the Diptera species have been cited as important pollinator insects in the arctic areas, particularly in view of their great abundance (e.g. KEVAN 1970, 1972). Our material also seems to indicate that the Diptera species, especially anthomyid flies, are more important than was suggested formerly. Although pollen carrying capacity seems to be rather limited, their abundant visits to female flowers suggest that they are largerly responsible for cloudberry pollination, at least in northern Fennoscandia.

The role which ants may play in cloudberry pollination is also sometimes suggested (see HAVAS 1970, LOHI 1974). In our study area they seemed to be rather insignificant both on account of their being rare in most localities and because of their poor pollen carrying capacity.

Thrips seem to pollinate some plants growing under unfavourable environmental conditions, such as *Calluna* in the Faroes (HAGERUP 1950) and species of Compositaeae in Iceland and Greenland (LEWIS 1973). Although thrips are often abundant on cloudberry flowers their role in pollination seem to be very questionable, because of their apparent poor mobility and pollen carrying capacity. The same applies to staphylinid beetles.

The experiments with excluders imply that small-sized insects are only of limited importance in the pollination biology of cloudberry. In the main similar observations were made on the pollination of *Rubus arcticus* L. by the reminiscent method (RYYNÄNEN 1973).

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Heikki Hippa and Seppo Koponen
Department of Zoology
University of Turku
SF-20500 Turku 50, Finland

SELOSTUS

Alustavia tutkimuksia suomuuraimen kukilla käyvistä hyönteisistä ja mahdollisista pölyttäjistä Pohjois-Lapissa

HEIKKI HIPPA ja SEPPO KOPONEN

Turun yliopisto

Koska muurain on taloudellisesti tärkeä luonnonmarja, tutkitaan nykyisin aktiivisesti sen luonnonvaraisen sadon parantamis- ja varmistamismahdollisuuksia sekä viljelyä. Pölytyksen onnistuminen on eräs satoon ratkaisevasti vaikuttavista tekijöistä. Toistaiseksi on ollut kuitenkin vähän tietoja muuraimen pölyttäjistä.

Nyt esitetyt tulokset perustuvat vuosina 1974—75 Utsjoen Lapista kerättyyn aineistoon. Pyrkimyksenä on ollut selvittää eri hyönteisryhmien runsautta kukissa. Lisäksi on selvitetty eri hyönteisten kuljettamaa siitepölymäärää ja koostumusta.

Kukissa viipyjiksi olemme kutsuneet ripsiäisiä ja lyhytsiipisiä kovakuoriaisia, koska niiden liikkuvuus kukasta toiseen näyttää olevan vähäistä. Määrät kukkaa kohti vaihtelivat tutkimuspisteitten välillä. Kummatkin ryhmät suosivat hedekukkia. Koska sekä ripsiäisten että lyhytsiipisten pölynkantokyky ja liikkuvuus on vähäistä, ei niillä liene suurtakaan merkitystä muuraimen pölyttäjinä.

Aktiivisesti kukasta toiseen liikkuvista hyönteisistä olivat runsaimpia kaksisiipiset, etenkin *Anthomyiidae-* ja *Empididae*-heimojen kärpäset. Vuonna 1974 olivat anthomyidit runsaimpina kaikissa tutkimuspisteissä, kun taas vuonna 1975 olivat empididit enemmistönä. Ero vuosien välillä voi johtua kesän 1975 poikkeuksellisesta kylmyydestä. Erityisesti anthomyidien pölynkantokyky ja runsaus antavat aiheen olettaa, että niillä on suurempi merkitys pölytykselle kuin aikaisemmin on oletettu.

Kimalaiset olivat harvalukuisia. Niitä esiintyi eniten kukinnan alkuvaiheessa, mutta *Ericaceae*-heimon kasvien kukinnan alettua kimalaiset siirtyivät pääasiassa niille. Vaikka tutkittujen kimalaisten pölymäärät olivat suuria, edellä mainitut seikat viittaavat kuitenkin siihen, että niiden merkitys pölytykselle on aikaisemmin luultua vähäisempi.

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Seria ANIMALIA NOCENTIA N. 79 — Sarja TUHOELÄIMET n:o 79

REARING THE UNIVOLTINE LADYBEETLES, COCCINELLA SEPTEMPUNCTATA AND ADALIA BIPUNCTATA (COL., COCCINELLIDAE), ALL YEAR AROUND IN THE LABORATORY

MATTI HÄMÄLÄINEN

HÄMÄLÄINEN, M. 1976. **Rearing the univoltine ladybeetles, Coccinella septempunctata and Adalia bipunctata (Col., Coccinellidae), all year around in the laboratory.** Ann. Agric. Fenn. 15: 66—71. (Agric. Res. Centre, Inst. of Pest Inv., SF-01300 Vantaa 30, Finland).

Coccinella septempunctata L. and *Adalia bipunctata* (L.) produce only one generation annually in Finland. Under laboratory conditions, however, applying a long photoperiod (LD 18: 6), several successive generations can be produced, a new generation emerging every 4th to 5th week.

Altogether nine *C. septempunctata* and ten *A. bipunctata* generations were reared. The majority of the females in each generation laid eggs. The average number of eggs per female, proportion of eggs that hatched, and development time and mortality in larvae and pupae varied in different generations, the variation being more irregular in *C. septempunctata*. The only significant signs of gradual stock degeneration were increasing mortality in larvae and pupae and a decreasing hatching rate of eggs in successive generations of *A. bipunctata*. On the other hand fecundity was increased in later generations of *C. septempunctata*.

The results show that it is possible to maintain a relatively viable laboratory culture of these ladybeetle species all year around for use in the biological control of aphids in greenhouses. However, the culture must be renewed each summer.

Index words: *Coccinella septempunctata, Adalia bipunctata,* laboratory rearing, voltinism, stock degeneration.

Introduction

Ladybeetles are univoltine in Finland. The adults usually emerge in July or August (CLAYHILLS and MARKKULA 1974) and reproduce after hibernation, the following summer. If ladybeetles are used for biological control of aphids in greenhouses they may be required at times when they are not available from the environment. There are two ways of filling this need: (1) a stock of dormant adults, collected from field or produced in laboratory, can be kept at low temperature, from which the beetles may be taken as required or (2) a laboratory culture can be maintained all year around under conditions suitable for reproduction and development. This paper deals with the latter possibility.

A degeneration in vigour has been observed in laboratory cultures of ladybeetles reared in successive generations. Both HODEK and ČERKASOV (1961) and HÄMÄLÄINEN and MARKKULA (1972) recorded increasing mortality in *Coccinella septempunctata* L. after about the 10th successive laboratory generation. ELLINGSEN (1969) reared four generations of *Adalia bipunctata* (L.) and found a gradual increase in mortality at all stages. Similar decreases in vigour in successive laboratory generations have also been observed in some other ladybeetles, for instance *Hippodamia convergens* (Guer.) (SHULL 1944) and *Propylaea quatuordecimpunctata* (L.) (ROGERS et al. 1972).

To obtain more information on this supposed stock degeneration and on the possibility of maintaining laboratory cultures of *C. septempunctata* and *A. bipunctata* all year around, successive generations of these species were reared under controlled conditions. The fecundity and mortality of adults, hatching rate of eggs, and development time and mortality in larvae and pupae were recorded for each generation in order to observe any signs of degeneration.

Material and methods

Overwintered adults of the species *C. septempunctata* and *A. bipunctata* were collected from the surroundings of the Agricultural Research Centre at the beginning of June 1974. One hundred beetles of both species were used to start laboratory breeding. Adults of the first *A. bipunctata* generation (progeny of the hibernated beetles) emerged in late July 1974, and those of *C. septempunctata* at the beginning of August 1974. After that a new generation was started every 4th to 5th week with 50 first-instar larvae, progeny of several different females. The larvae were reared singly in glass vials (diameter 2 cm, height 7 cm); development time and mortality was recorded. Larvae were fed with green peach aphids (*Myzus persicae* Sulz.) reared on green peppers or turnip rapes. Once a day the larvae were transferred to clean vials with a fresh supply of aphids. In each generation reserve set of larvae was reared simultaneously in a communal culture. Adults which had emerged from a communal culture were used only if the separately reared batch did not produce 40 viable adults. Larvae were reared in a temperature and moisture controlled rearing cabinet, temperature 25° ± 0.5° C and relative humidity of 80–90 %, with a photoperiod of 18 hours light and 6 hours dark.

In all generations forty adults of both species were placed in plastic jars (diameter 16 cm, height 9 cm), twenty beetles in each. The beetles were reared together for ten days so that copulation could take place, and were then put separately in smaller glass jars (diameter 9 cm, height 4 cm). Disks of filter paper had been placed at the bottom of the jars to retain moisture. The beetles were fed on green peach aphids. Once a day the jars were checked, the eggs laid removed and counted, and a fresh supply of aphids given. Adults were reared singly for 3 weeks and then killed (at the average age of 31 days). Females that had not laid eggs were dissected to check the developmental stage of ovaries. Females with undeveloped ovaries were considered to be in diapause (HODEK and ČERKASOV 1961).

The adults were reared in a laboratory room, where the average temperature varied from 22° to 26° C and relative humidity from 30 to 60 % for different generations. Humidity was, however, higher inside the rearing jars. The photoperiod was 18 hours light and 6 hours dark.

The hatching of eggs was studied at a temperature of 25° C (80–90 % R.H.). Egg clusters were kept singly in small glass vials. An average of 1200 eggs of *A. bipunctata* and 1500 eggs of *C. septempunctata* were studied in each generation.

The *C. septempunctata* generations were reared about 2—3 weeks later than those of *A. bipunctata*. Rearing ended in mid-July 1975, when aphids treated with insecticide were accidentally given to the ladybeetles. This caused high rate of mortality among the adults of the 11th *A. bipunctata* and the 10th *C. septempunctata* generations as it did in the larvae reared for the following generations. Results from these generations were deleted.

Results and discussion

The majority of the females in each generation started to lay eggs (Table 1). Consequently, the number of females in diapause was quite small. In many *A. bipunctata* generations all females laid eggs. The results resemble those obtained earlier by HÄMÄLÄINEN and MARKKULA (1972), who stated that diapause can be omitted in most females in *C. septempunctata* by rearing them under a long photoperiod (LD 18: 6). In this respect *A. bipunctata* seems to be similar to *C. septempunctata*. ELLINGSEN (1969), too, reared four generations of Norwegian *A. bipunctata* under a long photoperiod and found no signs of diapause.

A. bipunctata adults started to lay eggs a few days earlier than *C. septempunctata* in each generation. The shortest preoviposition periods for *A. bipunctata* ranged in different generations from 3 to 7 days, and those of *C. septempunctata* from 5 to 12 days. In later generations of both species the preoviposition period was usually shorter than in the first few generations. Within a generation egg-laying started more simultaneously in *A. bipunctata*. Some females in the first *C. septempunctata* generations did not have time to lay eggs during the 31 days but had developing ovaries when dissected.

The average number of eggs per female varied considerably in different generations (Figs. 1 and 2), the differences being more marked in *C. septempunctata*. In this species the average fecundity was significantly increased in successive generation (Table 3). The greater number of eggs laid in the later generations of *C. septempunctata* is partly due to the reduction in the preoviposition period. The mean number of eggs laid in all *C. septempunctata* generations (462 eggs) was slightly, though not significantly, greater than that in *A. bipunctata* generations (410 eggs).

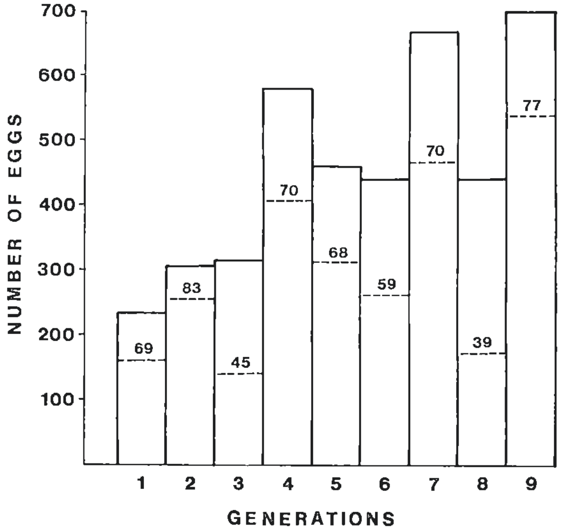

Fig. 1. Average fecundity and hatchability of eggs in successive generations of *Coccinella septempunctata*. Average fecundity = total number of eggs laid divided by the number of females with developed ovaries. Dotted line and the numbers in columns represent the percentage of hatched eggs.

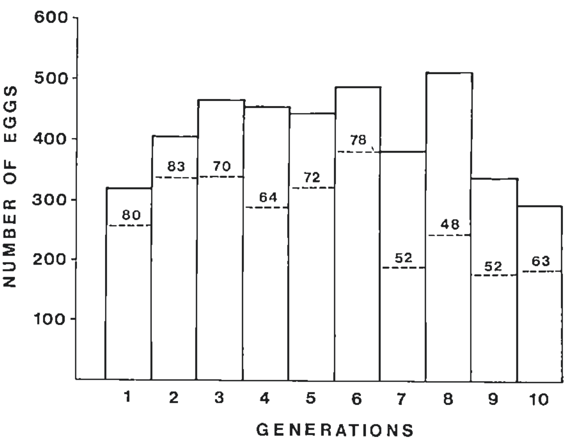

Fig. 2. Average fecundity and hatchability of eggs in successive generations of *Adalia bipunctata*. See text for Fig. 1.

Table 1. Successive generations of *Coccinella septempunctata* and *Adalia bipunctata*. Number of adults, percentage of females laying eggs, and adult mortality during the 31 days of the tests.

Generation	*Coccioella septempunctata* Number of males	Number of females	% of females laying eggs[1])	Mortality of males %	Mortality of females %	*Adalaia bipunctata* Number of males	Number of females	% of females laying eggs[1])	Morality of males %	Mortality of females %
1.	27	13	70	19	38	13	27	100	31	22
2.	13	27	96	0	11	15	25	68	0	0
3.	18	22	80	17	18	22	18	100	27	11
4.	21	19	81	57	32	16	24	100	13	4
5.	19	21	86	26	43	19	21	100	32	14
6.	22	18	89	23	11	19	21	100	5	10
7.	18	22	82	6	23	14	26	100	21	12
8.	18	22	77	22	18	17	23	96	12	13
9.	19	21	95	5	19	23	17	100	26	18
10.	13	27	85	—	—	22	18	83	23	28
11.	—	—	—	—	—	16	24	100	—	—

1) Females with developed ovaries included. Counted from the number of females alive after the age of 10 days.

Table 2. Development and mortality of larvae and pupae in successive generations of *Coccinella septempunctata* and *Adalia bipunctata*. Started with 50 first-instar larvae in each generation.

Generation	*Coccinella septempunctata* Total duration of larval and pupal instars, days Mean	Range	Mortality in larval and, pupal instars %	*Adalia bipuncata* Total duration of larval and pupal instars, days Mean	Range	Mortality In larval and pupal instars, %
1.	14.8	14—17	12	13.8	12—16	10
2.	13.9	14—17	4	12.9	11—14	2
3.	15.1	14—19	2	12.5	12—14	16
4.	16.8	15—18	20	13.8	13—15	4
5.	16.4	15—19	22	12.8	11—16	12
6.	16.5	15—20	2	12.8	12—14	10
7.	15.2	13—16	10	13.0	11—15	8
8.	14.6	14—16	28	12.9	12—15	22
9.	14.7	13—18	36	13.1	12—17	18
10.	15.0	14—18	4	13.3	11—15	28
11.	—	—	—	14.1	14—15	44

Table 3. Change in some biological properties of *Coccinella septempunctata* and *Adalia bipunctata* as a function of successive generations. Coefficients of correlation between the properties and the ordinal number of generations.

	Coccinella septempunctata	*Adalia bipunctata*
Percentage of females laying eggs	r = 0.214	r = 0.043
Average fecundity per female	0.798**	−0.158
Mortality of adult females	0.280	0.500
Mortality of adult males	−0.028	0.190
Hatchability of eggs	−0.200	−0.760**
Development time of larvae and pupae	0.004	0.196
Mortality of larvae and pupae	0.308	0.781**

Some of the adults died before the 31st day of their life. Mortality among adults did not increase significantly in successive generations in either species (Tables 1 and 3).

The hatching rate of eggs varied markedly in different generations. In *A. bipunctata* it decreased significantly in successive generations (Fig. 2, Table 3). With *C. septempunctata* hatching was irregular and no trend was discernible between different generations (Fig. 1). The percentage of all eggs that hatched in the course of the rearing experiments was

64.4 % in *A. bipunctata* (from about 12 000 eggs) and 65.7 % in *C. septempunctata* (14 000 eggs).

Development time from newly hatched larvae to adults was 1—3 days shorter in *A. bipunctata* than in *C. septempunctata* (Table 2). Variation in the development times in different generations was irregular. Mortality in larvae and pupae increased significantly towards the later generations in *A. bipunctata*, but not in *C. septempunctata* (Tables 2 and 3).

The only significant signs of gradual stock degeneration in the successive generations reared in this study, were the increase in larvae and pupae mortality and decreasing hatching rate of eggs of *A. bipunctata* (Table 3). Breeding ended due to a mishap and the original aim of rearing successive generations for as long as possible was not fulfilled. Thus the earlier observations stating that *C. septempunctata* cannot be produced after 10—13 successive generations (HODEK and ČERKASOV 1961, HÄMÄLÄINEN and MARKKULA 1972) could not be verified.

Some insects can be reared for years in the laboratory without any signs of degeneration. Reasons for the degeneration observed in ladybeetle cultures are likely genetic. SHULL (1944) assumed that inbreeding in the presence of semilethal genetic combinations, or the cumulative effect of unsuitable laboratory conditions might cause the decrease in vigour. According to MACKAUER (1976) inbreeding, selection and other random or nonrandom processes in laboratory cultures may lead to genetic decay, loss of fitness, or production of a laboratory ecotype unsuitable for use in the biological control.

It is also possible that artificial omission of the dormant period of an univoltine insect in many successive generations is involved in the decrease of vigour. Maintaining a laboratory culture of polyvoltine ladybeetles which reproduce all year around in nature may be more successful.

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Matti Hämäläinen
Agricultural Research Centre
Institute of Pest Investigation
SF-01300 Vantaa 30, Finland

SELOSTUS

Seitsenpiste- ja kaksipistepirkon ympärivuotinen laboratoriokasvatus

Matti Hämäläinen

Maatalouden tutkimuskeskus

Seitsenpistepirkosta ja kaksipistepirkosta kehittyy luonnossa vain yksi sukupolvi vuodessa. Tutkimuksen tarkoituksena oli selvittää, onko mahdollista ylläpitää jatkuvasti lisääntyvää seitsen- ja kaksipistepirkkokantaa pitkässä vuorokautisessa valaistuksessa labotoriossa. Vuoden aikana seitsenpistepirkosta kehittyi 9 ja kaksipispirkosta 10 perättäistä sukupolvea.

Kustakin sukupolvesta tutkittiin naaraiden munamäärä, munien kuoriutuvuus, toukkien ja koteloiden kehitysaika ja kuolleisuus, sekä aikuisten kuolleisuus. Kaksipistepirkkojen toukkien ja koteloiden kuolleisuus kasvoi ja niiden munien kuoriutuvuus heikkeni jonkin verran perättäisissä sukupolvissa. Vastaavaa vähittäistä elinkyvyn heikkenemistä ei todettu seitsenpistepirkolla. Seitsenpistepirkkojen munamäärät päin vastoin suurenivat perättäisissä sukupolvissa.

Tulokset osoittivat, että laboratoriossa on mahdollista ylläpitää elinkykyisiä seitsen- ja kaksipistepirkkokantoja vuoden ajan. Kanta on uudistettava joka kesä luonnosta kerätyillä leppäpirkoilla. Leppäpirkkojen jatkuva lisääntyminen mahdollistaa niiden käytön kirvojen biologiseen torjuntaan kasvihuoneissa vuodenaikoina, jolloin leppäpirkkoja ei ole luonnosta saatavana.

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Seria ANIMALIA NOCENTIA N. 80 — Sarja TUHOELÄIMET n:o 80

ÜBER DIE AN CRUCIFERAE LEBENDEN CEUTHORRHYNCHUS-ARTEN (COL., CURCULIONIDAE) FINNLANDS

ESKO KANGAS

KANGAS, E. 1976. **Über die an Cruciferae lebenden Ceuthorrhynchus-Arten (Col., Curculionidae) Finnlands [Ceuthorrhynchus species living on Cruciferae in Finland].** Ann. Agric. Fenn. 15: 72–80. (Dept. Agric. For. Zool., Univ. Helsinki, SF-00710 Helsinki 71, Finland).

Five species of the *Ceuthorrhynchus* genus (*C. pyrrhorhynchus* Marsh., *constrictus* March., *puncticollis* Boh., *gallorhenanus* Sol., *pervicax* Weise) which live on *Cruciferae* and are new to Finnish fauna are listed. Occurence in Finland of two species, *C. napi* Gyll. and *thomsoni* Kolbe, is uncertain and it must revise. The keys for the Finnish species of the two groups of species of the subgenus *Ceuthorrhynchus* s. str. and for those of the subgenus *Marklissus* Reitt. are given. The host plants of the Fennoskandian *Ceuthorrhynchus* species (30 Finnish species) living on *Cruciferae* are given and the 14 species which occur on cultivated crucifers in Finland. The biology of the last 9 species named is known very little or not at all.

Index words: *Ceuthorrhynchus, Cruciferae,* keys, host plants.

Untersuchungen über die *Ceuthorrhynchus*-Arten haben die Anzahl der an *Cruciferae* lebenden Arten Finnlands in der letzten Zeit mit mehreren neuen Arten erhöht. Manche von diesen Arten sind oligophag, und die Biologie sowie die Anforderungen an ihre Wirtspflanzen der anderen sind wenig oder kaum bekannt. Weil aber wenigstens ein Paar von den neuen Arten auch landwirtschaftliche Bedeutung haben oder haben können, ist ein zusammenfassender Überblick über die heutige bei uns an *Cruciferae* lebende Fauna gerechtfertigt.

Die für die Fauna Finnlands neuen an *Cruciferae* lebenden Arten seit Jahr 1960

Der nordische *Coleoptera*-Katalog (HANSEN et al. 1960) enthält die jüngste Liste der finnischen *Ceutorrhynchus*-Arten. Seitdem sind mehrere neue Arten angemeldet worden. Von diesen Arten leben die meisten an *Cruciferae*, nämlich folgende:

1. *Ceuthorrhynchus* (*Calosirus* Thoms.) *pyrrhorhynchus* Mars. — Ich habe einige Exemplare von V: Dragsfjärd (Insel Örö) 11. 7. 1971 zu-

sammen mit einigen *Marklissus*-Arten (*contractus* Marsh., *erysimi* Fabr., *sulcicollis* Payk.) gesammelt (gemeldet als eine neu Art zur Fauna Finnlands in der Sitzung der Finnischen Entomologischen Gesellschaft am 19. 12. 1975) (KANGAS 1976). Die Art lebte dort an *Sisymbrium*.

2. *C.* (*Ceuthorrhynchus* s.str.) *constrictus* Marsh. — Nur ein Exemplar von U: Pyhtää (MUONA 1975). Die Art wurde am 20. 5. 1973 zusammen mit *C. pulvinatus* Gyll. von verschiedenen unbestimmten *Cruciferae* geketschert (Muona leg., Kangas det.).

3. *C.* (*Ceuthorrhynchus* s. str.) *puncticollis* Boh. — Mehrere Exemplare von ES: Lappeenranta (KANGAS 1975). Die Art wurde am 8. 6. 1971 auf einer Wiese mit verschiedenen *Cruciferae* (*Berteroa*, *Brassica*, *Erysimum*, *Raphanus*, *Turritis* etc.) geketschert.

4. *C.* (*Ceuthorrhynchus* s. str.) *gallorhenanus* Sol. — Bisher selten in allersüdlichsten Teil des Landes (KANGAS 1975). Die Art ist wahrscheinlich auch aus Versehen unbeachtet geblieben. Die Art wurde zum ersten Mal — soweit wie nun bekannt — schon im Jahre 1920 in Finnland gefunden. Die bisher bekannten Funde:

V: Turku (Ruissalo) 4. 7.1960 (2. Exx., Kangas leg.), Lohja 2. 5. 1920 (1 Ex. Har. Lindberg leg.). U: Tvärminne 23. 8. 1955 (2 Exx., Håk. Lindberg leg.), Helsinki 16. 6. 1942 (1 Ex., Har. Lindberg leg.), Helsinki (Pasila) 1. 7. 1940 (einige Exx., V. Karvonen leg., und Helsinki (Munkkiniemi) 23. 7. 1941 (1 Ex., S. Stockmann leg.). EK: Virolahti 3. 7. 1961 (1 Ex., Kangas leg.). ES: Joutseno 12.—13. 6. 1956 (1 Ex., Håk. Lindberg leg.), Imatra 8.—11. 6. 1956 (1 Ex., Håk. Lindberg leg.). — Kangas det.

5. *C.* (*Marklissus* Reitt.) *pervicax* Weise. — Bisher nur drei Exemplare von Finnland:

U: Hyvinkää (Kytäjä) 18. 5. 1969, 1 Ex. (KANGAS 1976) und Siuntio 10. 3. 1975 (1 Ex., J. Muona leg.). ES: Joutseno, (?) (1 Ex., E. Thuneberg leg.).

Die Arten der *Ceuthorrhynchus pleurostigma-roberti* -Gruppe

In der *C. pleurostigma-roberti* -Gruppe (die 8. Artgruppe, HANSEN 1965) gibt es einige, bei uns landwirtschaftlich wichtige Arten, vie *C. pleurostigma* Marsch., *C. rapae* Gyll., und *C. napi* Gyll. (SAALAS 1933, VAPPULA 1965). Die Biologie und die landwirtschaftliche Bedeutung von manchen Arten dieser Gruppe ist jedoch mangelhaft oder gar nicht bekannt, wie z.B. die von der neuen Art *C. puncticollis*. Die Arten der Gruppe bieten auch gewisse Schwierigkeiten bei der Determinierung, insbesondere weil einige Arten in den bei uns verfügbaren Bestimmungstabellen fehlen oder nach diesen schwierig zu bestimmen sind.

Die finnischen Arten der Gruppe sind nach der folgenden Bestimmungstabelle zu determinieren:

1 (2) Halsschild an den Seiten mit der vollen Rundung, ohne Spuren vom Seitenhöcker, in der Mitte zusammenfliessend punktiert, fein chagriniert. Flügeldecken mit starken tiefen Punktstreifen, diese auf dem Grunde mit sehr kleinen, kaum sichtbaren weissen Schuppen, Streifenintervalle kaum breiter als Punktstreifen .... *inaffactatus* Gyll.

2 (1) Halsschild mit deutlichen Seitenhöckern, wenn mit sehr kleinen Höckern oder nur einer Ecke an der Rundung (*rapae*, *napi*), dann Flügeldecken mit schmalen, nicht tiefen Punktstreifen und breiten platten Streifenintervallen. Punkstreifen auf dem Grunde mit deutlichen weissen Schuppen 3

3 (4) Klein 1.5—2.0 mm. Mittelfurche des Halsschilds seicht, in der Mitte unterbrochen und der oberste Teil der Epimeren der Mittelbrust kaum dichter weiss beschuppt als die andere Teile der Epimeren .... *griseus* Bris.

4 (3) Grösser, 2.5—3.6 mm. (Wenn kleiner, dann der oberste Teil der Epimeren der Mittelbrust sehr dicht beschuppt, einen den Grund vollständig bedeckenden Fleck bildend: kleine Exx. von *pleurostigma*) 5

5 (6) Fühlerschaft in der letzten Hälfte gegen die Spitze gleichmässig verdickt. Halsschild mit sehr feinen Härchen licht bedeckt (Härchen dünn und gleichdick) 7

6 (5) Fühlerschaft gegen die Spitze plötzlich (± keulenartig) verdickt. Halsschild mit breiteren etwas schuppenartigen Haaren licht bedeckt (Haare gewöhnlich an der Basis breiter, gegen die Spitze deutlich verengt, scharfspitzig) .. 9

7 (8) Halsschild mit voller (in der Mitte etwas niedriger) Mittelfurche, gröber und in der Mitte zusammenfliessend punktiert. Halsschildhöckerchen sehr klein, oft nur eine

kleine Ecke an der Rundung der Seiten. Kleiner (2.5–3.0 mm) und etwas schmäler .... *rapae* Gyll.

8 (7) Halsschildmittelfurche in der Mitte unterbrochen, Punkte kleiner, getrennt. Halsschild mit deutlicher Ecke an der Rundung der Seiten. Grösser (3.2–3.6 mm) und etwas breiter .... *napi* Gyll.

9 (10) Der oberste Teil der Epimeren der Mittelbrust sehr dicht, bedeckend beschuppt. Punktur des Kopfes fein, auf dem Halsschild etwas gröber (doch noch ziemlich fein). Fühlerschaft ung. so lang wie die vier ersten Geisselglieder zusammen ...... *pleurostigma* Marsh.

10 (9) Epimeren der Mittelbrust überall gleichartig und sehr licht beschuppt. Punktur des Kopfes und des Halsschilds grob bis sehr grob 11

11 (12) Fühlerschaft lang, länger als die vier ersten Geisselglieder zusammen. Punktur des Kopfes und des Halsschilds ung. gleich grob. Punktstreifen der Flügeldecken viel schmäler als Streifenintervalle .... *roberti* Gyll.

12 (11) Fühlerschaft kurz, kürzer als die vier ersten Geisselglieder zusammen. Halsschild viel gröber als Kopf punktiert. Punktstreifen der Flügeldecken kaum schmäler als Streifenintervalle .... *puncticolls* Boh.

Ceuthorrhynchus assimilis Payk. und *gallorhenanus* Sol.

Die zur der *C. assimilis* Gruppe (die 9. Artgruppe, HANSEN 1965) gehörenden Arten sind alle an *Cruciferae* lebend. Zur finnischen Fauna hat man bisher nur vier von diesen Arten gerechnet (*C. assimilis* Payk., *C. cochleariae* Gyll., *C. querceti* Gyll. und *C. atomus* Boh.). Von den für unsere Fauna neuen Arten kommen zu dieser Gruppe noch zwei Arten hinzu, *C. gallorhenanus* Sol. und *C. constrictus* Marsh.

Wie bekannt, ist *C. assimilis* ein sehr wichtiger Schädling des Winterrübsens und einiger anderer landwirtschaftlich wichtiger *Cruciferae* (gewisse *Brassica*-Arten u.a.). Bei uns war die Art früher wenig bekannt und nich weit verbreitet, also eine seltene Art, nach SAHLBERG (1900) nur in den Provinzen A, V und U (Al, A und N) gefunden. Nach dem Beginn des Anbaues von Winterrübsen verbreitete sie sich aber rasch über Südfinnland und wurde viel häufiger als sie früher gewesen war. Der Winterrübsenbau hat deutlich dazu beigetragen, dass die Art sich nun so verbreitet hat — bis zu den Provinzen PH (Virrat, 1964 Kangas leg. und Laukaa — sieh ROIVAINEN 1957) und EP (Laihia 1957, Kangas leg.; Ilmajoki und Ylistaro — sieh ROIVAINEN 1957) — und ein von den ärgsten Schädlingen des Winterrübsens ist (SAALAS 1933, VAPPULA 1965).

Eine *C. assimilis* sehr nahe stehende Art ist *C. gallorhenanus*. Diese Art ist schon in den verschiedenen Teilen Mitteleuropas als ein wichtiger Schädling der angebauten *Cruciferae* genannt worden (z.B. HOFFMANN 1955). In den nordischen Ländern wurde die Art erst in den letzten Jahren konstatiert (vgl. HANSEN et al. 1960), wie z.B. bei uns erst 15. 3. 1974 (KANGAS 1975). Sie ist allerdings in Finnland mindestens schon 1920 gefunden (sieh S. 73), aber falsch als *C. assimilis* determiniert worden. Sie durfte jedoch kaum ein junger Einwanderer bei uns sein, sondern eher eine übersehene Art, wie sie wahrscheinlich in ganz Europa gewesen ist (die Art wurde erst 1949 beschrieben, SOLARI 1949).

Die wichtigsten Unterschiede zwischen *C. assimilis* und *C. gallorhenanus* sind folgende:

	C. assimilis	*C. gallorhenanus*
Fühler	Schaft schwäcker gegen die Spitze verdickt, an der Spitze 2½ mal so dick wie in der Mitte.	Schaft stärker gegen die Spitze verdickt, an der Spitze 3mal so dick wie in der Mitte.
Halsschild	etwas schmäler, höchstens 1¼ mal so breit wie lang, Seitenhöcker ein wenig kleiner und die Einsenkung davor seicht, und Halschild deshalb gleichmässiger nach vorn verengt.	etwas breiter, mehr als 1¼ mal so breit wie lang, Seitenhöcker etwas grösser und die Einsenkung davor deutlich stärker, ziemlich tief und weit, und Halsschild deshalb ziemlich schroff nach vorn verengt.

Flügeldecken Streifenintervalle etwas schmäler, 2-reihig (zum Teil 1-reihig) fast anliegend braunlich behaart (Haare etwas schuppenartig, spitzig), Schuppen auf dem grunde der Punktstreifen kurz, nur ung. die Hälfte von der Entfernung zwischen den Punkten, und sie bilden eine typische gestrichelte Linie; äussere Streifenintervalle sehr selten mit einigen wenigen breiteren weissen Schuppen, gewöhnlich ganz ohne.

Streifenintervalle ein wenig breiter, unregelmässig 2—3-reihig, ganz anliegend weiss beschuppt (Schuppen gleichbreit, meistens ganz stumpf), Schuppen auf dem Grunde der Punktstreifen lang, sie erreichen fast einander und bilden eine beinahe ununterbrochene Linie; auf den äusseren und oft auch einigen inneren Streifenintervallen die weissen Schuppen zum Teil viel breiter als die anderen.

Die finnishen Arten der Untergattung *Marklissus* Reitt.

Die Anzahl der finnischen *Marklissus*-Arten hat sich nach den 1930-Jahren einigemale geändert. In der "Enumeratio Insectorum Fenniae" (V, Coleoptera; HELLÉN 1936) und im "Catalogus Coleopterorum Daniae et Fennoscandiae" (HANSEN et al. 1939) gibt es acht Arten vom ostfennoskandischen Gebiet (sowie auch von den alten staatlichen Gebieten Finnlands). Nach der späteren Enumeratio (Fenniae et Sueciae, HELLÉN 1947) kommen schon neun Arten in diesem Gebiet vor und nach dem letzten Katalog (HANSEN et al. 1960) elf Arten. Heutzutage sind aus diesem Gebiet 12 Arten gemeldet und — eine neue Art, *C. pervicax*, mitgerechnet — aus dem finnishen staatlichen Gebiet 11 Arten. (s. unten). Alle diese Arten leben an *Cruciferae*.

Im ganzen fennoskandischen Gebiet sind bisher 13 *Marklissus*-Arten angetroffen worden. Ich füge hier eine Bestimmungstabelle für diese Arten bei (die ausserhalb des finnischen staatlichen Gebiets vorkommenden Arten in Klammern):

1 (2) Klauen einfach. (Alle Arten haben die anliegende Behaarung auf den Streifenintervallen der Flügeldecken) 3

2 (1) Klauen gespalten (die inneren Teile kürzer und gewöhnlich dunkler) 7

3 (4) Schenkel mit einem von weissen dichtstehenden Schuppen bekleideten Zähnchen. Streifenintervalle der Flügeldecken sehr kurz und dicht anliegend behaart ...... *scapularis* Gyll.

4 (3) Schenkel ohne Zahn oder Schuppengruppe. Streifenintervalle mit langen Haaren behaart (Haare reichen zueinander, in der Mitte ein wenig gehoben) 5

5 (6) Streifenintervalle der Flügeldecken breiter (ung. 3mal so breit wie Punktstreifen), Haare kürzer, hell, hauptsächlich in einer Reihe. Gewöhnlich hellfarbig, grünlich- bis violettblau, grösser (1.7—2.3 mm) .... *erysimi* Fabr.

6 (5) Streifenintervalle der Flügeldecken schmäler (ung. 2mal so breit wie Punktstreifen), Haare länger, braun, oft hier und da in zwei Reihen. Dunkelblau-schwarzblau, kleiner (1.3—1.5 mm) .... *contractus* Marsh.

7 (8) Halsschild und Flügeldecken mit stark aufgehobenen feinen langen Haaren und dazwischen mit zahlreichen anliegenden gelblichweissen Schuppen. Schwarz, Tarsen hell geblichbraun[1] .... *quadridens* Panz.

8 (7) Halsschild und Flügeldecken anliegend oder aufgehoben behaart, höchstens auf dem Halsschild in der Mitte und dicht hinter dem Schildchen wenige helle weisse Schuppen. Tarsen dunkel. Metallisch grün-blau-violett (eine Art schwarz: *C. atomus*, sie hat aber nicht zahlreiche anliegende Schuppen auf den Flügeldecken: 17) 9

9 (10) Streifenintervalle der Flügeldecken ganz anliegend 2- bis 3-reihig (wenn nur einreihig, dann Halschild metallisch: *C. pectoralis*, sieh 10) behaart. Halsschild schwarz 11

10 (9) Streifenintervalle der Flügeldecken mit aufgehobenen (bei *C. pectoralis* mit sehr wenig aufgehobenen, fast anliegenden) Haaren in einer Reihe. Halsschild metallisch gefärbt (bei *C. atomus* schwarz) 17

11 (12) Fühlerschaft keulig verdickt. Punktstreifen auf dem Grunde mit deutlich sichtbaren weissen Schuppen .... (*viridanus* Gyll.)

[1] Nach HANSEN (1965) gehört diese Art zu einer eigenen (der 10.) Artengruppe und nicht zu der 11. Gruppe, wohin die Arten der Untergattung *Marklissus* gestellt worden sind.

12 (11) Fühlerschaft nicht keulig, sondern allmählich verdickt. Punktstreifen auf dem Grunde kahl 13

13 (14) Streifenintervalle der Flügeldecken flach und breit (2 oder 3mal so breit wie die Punktstreifen in der Mitte der Flügeldecken), Haaren auf den Intervallen wenigstens zum Teil in drei Reihen. Punktstreifen scharf aber schmal oder ziemlich schmal 15

14 (13) Streifenintervalle der Flügeldecken ± gewölbt (am meisten die seitlichsten) und schmal (höchstens etwas — an den Seiten nicht — breiter als die Punktstreifen), Haare auf den Intervallen sehr kurz (reichen bei weitem nicht zueinander) und nur in zwei Reihen (immer zum Teil auch in einer Reihe). Punktstreifen sehr stark und breit (offen), am Grunde und an der Seiten deutlich gerundet, so dass sie und die Intervallen im Querschnitt wellenartig laufen. Halsschild deutlich chagriniert . . . . *pervicax* Weise

15 (16) Grösser (2.7—3.2 mm). Streifenintervalle der Flügeldecken sehr breit, 3mal (oder mehr) so breit wie die schmalen, ganz senkrechten, nicht starken Punktstreifen, Haare auf den Intervallen sehr kurz (reichen bei weitem nicht zueinander), zum grossen Teil in drei Reihen. Halsschild deutlich chagriniert . . . . *barbarae* Suffr.

16 (15) Kleiner (2.0—2.6 mm). Streifenintervalle der Flügeldecken (in der Mitte) nur 2mal so breit wie die ziemlich starken, etwas an den Seiten (gegen die Intervalle) gerundeten Punktstreifen, Haare auf den Intervallen lang (reichen sogar übereinander), gewöhnlich in zwei, nur hier und da in drei Reihen. Halsschild nicht (oder nur sehr schwach, schwer wahrnehmbar) chagriniert . . . . *ignitus* Germ.

17 (18) Schwarz. Auf den gewölbten schmalen Streifenintervallen der Flügeldecken eine Reihe fast aufrechte und gerade, weisse-weissliche borstartige Haare. Punktstreifen breit, nur wenig schmäler als Intervalle. Tarsenglieder, wenigstens die zwei letzten, etwas rötlich[1] . . . . *atomus* Boh.

18 (17) Flügeldecken metallisch (grün-blau-violett), die gehobenen Haaren auf den (±flachen oder gewölbten) Intervallen gebogen, nur schräg nach hinten gehoben, dunkler (bräunlich bis schwarz) 19

19 (20) Fühlerschaft gegen die Spitze allmählich verdickt. Drittes Tarsenglied gewöhnlich (wenigstens and der Spitze) rötlich. Rüssel bis zur Fühlereinlenkungsstelle gekielt . . . . *sulcicollis* Payk.

20 (19) Fühlerschaft gegen die Spitze keulig verdickt. Drittes Tarsenglied nicht heller (rötlich) als die anderen 21

21 (22) Punktstreifen der Flügeldecken auf dem Grunde mit weissen Schuppen; Haare auf den Intervallen schwarz. Rüssel bis zur Fühlereinlenkungsstelle gekielt . . . . *hirtulus* Germ.

22 (21) Punktstreifen der Flügeldecken auf dem Grunde kahl, Haare auf den Intervallen hell, bräunlich. Rüssel ungekielt 23

23 (24) Mittel- und Hinterbrust dicht (bedeckend) weisslich beschuppt. Streifenintervalle der Flügeldecken breiter (wenigstens 2mal so breit wie Punktstreifen), und sehr flach gewölbt . . . . (*pectoralis* Weise)

24 (23) Mittel- und Hinterbrust nicht dicht, sondern so wie die ganze Unterseite licht beschuppt. Streifenintervalle der Flügeldecken schmäler (kaum oder nur wenig — höchstens 1.5 mal — breiter als Punktstreifen) und mässig oder sehr deutlich gewölbt 25

25 (26) Halsschild und Kopf zwischen den dicht stehenden Punkten deutlich chagriniert. Auf dem äussersten Streifenintervalle — statt der aufgehobenen Haare — gewöhnlich einige längliche weisse, dicht anliegende Schuppen. Vorderrand des Halsschilds an den Seiten zwischen dem ebenen Oberteil und den an dem unteren Seitenteil sich befindenden Wimperhaaren nur wellig, ohne kleine zahnartige Tuberkeln . . . . (*thomsoni* Kolbe)

26 (25) Halsschild und Kopf am Grunde glatt oder ± deutlich licht chagriniert. Alle Streifenintervalle der Flügeldecken behaart, ohne weisse Schuppen. Vorderrand des Halsschilds an dem oberen Seitenteil wellig und mit kleinen zahnartigen Tuberkeln . . . . *chalybaeus* Germ.

Die Arten *C. ignitus* und *pervicax* sowie auch *C. thomsoni* und *chalybaeus* bilden jeweils miteinander ein sehr nahestehendes Artenpaar, was gewisse Schwierigkeiten für die Determinierung macht. Die Arten des erstgenannten Paars kann man jedoch sicher nach den gegebenen Kennzeichnen — insbesondere nach der Wölbung und der Haarlänge der Streifenintervalle — bestimmen. Die Unterschiede zwischen *C. thomsoni* und *C. chalybaeus* sind mehr unbestimmt, weil einerseits die läng-

[1] *C. atomus* ist hier zur Untergattung *Marklissus* gezählt worden, wie z.B. SMRECZYŃSKI (1974) gemacht hat. REITTER (1916) selbst hat nicht sie in seiner neuen Untergattung gestellt.

lichen anliegenden weissen Schuppen auf dem letzten Streifenintervall der Flügeldecken bei der erstgenannten gänzlich ausgerieben sein können, und anderseits weil auch bei *C. chalybaeus* der Halsschild — oft mehr oder weniger, sogar so wie bei *C. thomsoni* — chagriniert sein kann. STRAND (1960) hat dieses Artenpaar genau studiert und hat auch die Genitaluntersuchungen gemacht und die Aedeagi (mit Bildern) beschrieben. Sie sind sicher zwei verschiedene Arten, das beste morphologische Kennzeichen (die länglichen weissen Schuppen auf den letzten Streifenintervallen), ist aber nur etwas unsicher. Diese zwei Arten sind jedoch in manchen Fällen auch ohne Genitalpräparate zu bestimmen (vgl. auch HANSEN 1965 und SMRECZYŃSKI 1974). — *C. thomsoni* ist in unserem letzten Catalogus (HANSEN et al. 1960) als eine zur finnischen Fauna gehörende Art gerechnet worden (vgl. HELLÉN 1961). Ich habe ein ziemlich grosses *Marklissus*-Material (die Sammlungen des Entomol. Museums und des Instituts für Land- und Forstwirtsch. Zoologie der Universität Helsinki sowie Sammlungen von Lindberg, Stockmann, Y. Kangas, Muona, Rutanen und meine eigene Sammlung) revidiert, habe aber kein sicheres *C. thomsoni*-Exemplar finden können. Meiner Meinung nach ist das Auftreten der Art bei uns unsicher und sollte noch genau kontrolliert werden.

Die an *Cruciferae* lebenden finnischen Arten der Gattung *Ceuthorrhynchus* Germar

In der Literatur gibt es sehr viele Angaben über die Wirtspflanzen der *Ceuthorrhynchus*-Arten (z.B. REITTER 1916, HOFFMANN 1954, HANSEN 1965, SMRECZYŃSKI 1974), so dass es möglich ist, auch die Wirtspflanzen der finnischen Arten ermitteln. Manche in Finnland angetroffenen Arten leben jedoch nach diesen Angaben an solchen *Cruciferae*, die hier nicht vorkommen. Wir haben allerdings eigene Beobachtungen von einigen dieser Arten (vgl. z.B. VAPPULA 1965, ROIVAINEN 1957), diese Angaben sind aber aller Wahrscheinlichkeit nach noch ziemlich unvollständig. Ich füge hier eine Liste von den Wirtspflanzen der an *Cruciferae* lebenden fennoskandischen Arten bei.

Art	Wirtpflanze	
	Literaturangaben[1]	Beobactungen in Finnland[1]
C. floralis Payk.	*Cruciferae*	*Cruciferae* *Arabis, Capsella, Sisymbrium, Thlaspi*
C. cacilis Hans.	*Cacile, Crambe*	*Cacile, Crambe*
(*C. rhenanus* Schultze[2])	*Alliaria, Erysimum, Thlaspi*	—
(*C. obsoletus* Germ.)	(? *Cruciferae*)	—
C. pyrrhorhynchus Marsh.	*Sisymbrium*	*Sisymbrium*
C. pulvinatus Gyll.	*Cruciferae* *Descurainia sophia, Isatis, Sisymbrium loeselii*	*Cruciferae* *Sisymbrium*
C. hampei Bris.	*Berteroa incana, Thlaspi*	*Berteroa incana*
(*C. posthumus* Germ.)	*Lepidium*	—
C. querseti Gyll.	*Rorippa* (Nasturtium)	
C. pleurostigma Marsh.	*Cruciferae*	*Cruciferae** *Brassica, Raphanus*
C. roberti Gyll.	*Alliaria*	*Armoracia**
C. puncticollis Boh.	*Berteroa, Erysimum*	*Cruciferae* : ? *Berteroa*
C. griseus Ch. Bris.	*Cruciferae* *Arabidopsis, Cardamine, Cochlearia, Lepidium, Sinapsis*	
C. napi Gyll.	*Alliaria, Barbarea, Brassica, Isatis, Raphanus, Rorippa, Sisymbrium*	?*
C. rapae Gyll.	*Cruciferae* *Brassica, Caradria drapa, Cardamine, Descurainia, Erysimum, Isatis, Lepidium, Sisymbrium*	*Cruciferae** *Brassica* (*Brassica rapa oleifera*), *Armoracia*

C. assimilis Payk.	*Cruciferae* *Brassica*, *Raphanus* etc.	*Cruciferae** *Armoracia*, *Brassica*, *Matthiola*, *Raphanus*
C. gallo-rhenanus Sol.	*Cruciferae* *Brassica* etc.	*Brassica**, *Raphanus*
C. inaffectatus Gyll.	*Hesperis*, *Alliaria*	*Hesperis*
(*C. syrites* Germ.)	*Cruciferae* *Alyssum*, *Brassica*, *Camelina*. *Caradria*, *Sinapsis*	—
C. constrictus Marsh.	*Alliaria*	(*Cruciferae*)
C. cochleariae Gyll.	*Arabidopsis*, *Armoracia* (*Cochlearia*), *Cardamine*	*Cardamine*, *Armoracia**
C. sophiae Stev.	*Descurainia* (*Sisymbrium*) *sophia*	—
(*C. unguicularis* Thoms. (*schönherri* Ch. Bris.))	*Arabis*	
(*C. granulicollis* Thoms.)	*Thlaspi*	—
C. atomus Boh.	*Alliaria*, *Arabidopsis*, *Arabis*, *Cardamine*, *Draba*, *Erophila verna*, *Isatis*	
C. quadridens Panz.	*Cruciferae* *Brassica*, *Raphanus*, *Sinapsis* etc.	*Cruciferae** *Brassica* (*Brassica rapa oleifera*), *Matthiola*
C. sulcicollis Payk.	*Cruciferae* *Brassica*, *Sisymbrium*, *Sinapsis* etc.	*Cruciferae** *Brassica*, *Sisymbrium*
C. scapularis Gyll.	*Rorippa* (*amphibia*)	
C. barbarae Suffr.	*Barbarea*, *Rorippa* (*Nasturtium*)	*Barbarea*
C. pervicax Weise	*Cardamine*, *Dentaria*, *Nasturtium officinale*, *Rorippa*	(*Brassica*/*Barbarea*)
(*C. viridanus* Gyll.)	*Erysimum hieracifolium*	—
C. ignitus Germ.	*Berteroa incana*, *Armoracia lapathifolia*	*Berteroa incana*
C. erysimi Fabr.	*Cruciferae* *Capsella* etc.	*Cruciferae** *Brassica*, *Capsella*, *Draba*, *Sisymbrium*
C. contractus Marsh.	*Cruciferae* (über 100 Arten)	*Cruciferae** *Brassica*, *Sisymbrium*
C. hirtulus Germ.	*Arabidopsis*, *Arabis*, *Cardamine*, *Erophila verna*, *Nasturtium officinale*, *Sinapsis arvensis*	
(*C. pectoralis Schultze*)	*Barbarea*, *Cardamine*, *Rorippa*, *Thlaspi*	*Cardamine* (USSR: Kk, Uusikirkko 1935)
C. chalybaeus Germ.	*Cruciferae* *Brassica*, *Raphanus*, *Sinapsis*, *Sisymbrium*	*Cruciferae** *Brassica rapa oleifera*
(*C. thomsoni* Kolbe)	*Alliaria*, *Berteroa incana*, *Brassica campestris*	—

[1] Literaturangaben (nur in Finnland vorkommenden Gattungen und Arten genannt) rühren hauptsächlich von HOFFMAN (1954), HANSEN (1965), KOCH (1967) und SMRECZYŃSKI (1974), die in finnischen Boebachtungen von ROIVAINEN (1957), VAPPULA (1965) und von einigen finnischen Koleopterologen her; dazu kommen meine eigene Beobactungen.

[2] (—) = Noch nicht in Finnland getroffene fennoskandische Arten.

* = In Finnland an den angebauten *Cruciferae* getroffen.

Zu allen vorher behandelten Artengruppen gehören Arten, welche — wie gesagt — eine landwirtschaftlich beträchtliche Bedeutung besitzen. Dazu kommen Arten, welche — ausser an ihren naturgemässen Wirtspflanzen — auch an den angebauten *Cruciferae* vorkommen können, welche hinsichtlich ihrer Biologie wenig bekannt sind. Die wichtigsten solchen Arten, welche man also genauer studieren sollte, sind offenbar folgende:

C. roberti: Die Art ist bis nach Nordfinnland (EP, PS, KP, PP, KS) verbreitet. Sie lebt nach den Literaturangaben (REITTER 1916, HANSEN 1965, SMRECZYŃSKI 1974) an *Alliaria*, welche Art bei uns im Binnenland nicht vorkommt. Sie ist auch an den angebauten *Cruciferae* konstatiert geworden (VAPPULA 1965).

C. napi: Das Vorkommen dieser Art in Finnland ist sehr schlecht bekannt (ich kenne keine sicheren Funde der Art aus dem heutigen staatlichen Gebiet des Landes!). SAALAS (1933) erwähnt sie jedoch als eine landwirtschaftlich beachtenswerte Art (vgl. auch SMRECZYŃSKI 1974).

C. gallorhenanus: Man weiss (z. B. HOFFMANN 1955), dass die Art ungefähr dieselbe Biologie hat wie *C. assimilis* (ein bekannter Schädling). Es hat sich unerwartet erwiesen, dass die Art in Finnland mindestens schon seit 1920 vorkommt. Welchen Anteil hat sie möglicherweise an den Schädigungen von *C. assimilis* gehabt? Sie ist mehrmals auch bei uns zusammen mit C. *assimilis* gefunden worden.

C. erysimi: Die Art ist eine von den häufigsten und meist verbreiteten in Finnland. Obgleich bisher keine Meldungen über die Art als Schädling vorliegen, ist sie so häufig auch an den angebauten *Cruciferae* gefunden worden, dass eine genauere Untersuchung über ihre Biologie und Anforderungen hinsichtlich ihrer Wirtspflanze sehr wünschbar wären.

C. contractus: Vielleicht die häufigste Art ihrer Untergattung bei uns (verbreitet über das ganze Land). Sie ist ein paarmal als ein wahrscheinlicher Schädling gemeldet worden (VAPPULA 1965) und als solcher im Ausland bekannt (SAALAS 1933).

C. sulcicollis: Diese Art ist schon im Südfinnland sehr häufig geworden — ganz so wie *C. assimilis* (sieh S. 74) nach dem Beginn des Anbaues von bei uns neuen *Cruciferae* wie Winterrübsen usw., nur zwei-drei Jahrzehnte später. Auch ihre naturgemässen Wirtspflanzen sind u.a. *Brassica-* und *Raphanus-* Arten (z.B. SMRECZYŃSKI 1974). — Oft zusammen mit dieser Art hat man auch *C. barbarae* getroffen, wie auch *C. pervicax* (sieh S. 78). Die Biologie dieser Arten ist fast vollständig unbekannt.

C. chalybaeus: Die Art ist bei uns einmal von einer angebauten Wasserrübe gezüchtet worden (VAPPULA 1965). Sie lebt an den sehr zahlreichen Kreuzblütlern und ist bis zum Nordfinnland (KP: Haapavesi, PP: Oulu und Rovaniemi) verbreitet.

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Esko Kangas
Lantwirtschaft- und Forstzoologisches
Institut der Universität Helsinki
Viikki
SF-00710 Helsinki 71, Finnland
Gegenwärtige Adresse
Alkutie 66 A
SF-00660 Helsinki 66, Finnland

SELOSTUS

Ristikukkaisilla Suomessa elävistä Ceuthorrhynchus-lajeista (Col., Curculionidae)

ESKO KANGAS

Helsingin Yliopisto[1])

Viime vuosina suoritettujen *Ceuthorrhynchus*-sukua koskevien tutkimusten yhteydessä on todettu viisi maassamme aikaisemmin tuntematonta ristikukkaisilla elävää lajia, *C. pyrrhorhynchus* Marsch., *C. constrictus* Marsch., *C. puncticollis* Boh., *C. gallorhenanus* Sol. ja C. *pervicax* Weise. Kun kolmen viimeksi mainitun sekä eräiden muiden meillä tavatuksi ilmoitettujen lajien määrittäminen tavallisesti käytettävissä olevien määritysteosten mukaan tuottaa vaikeuksia tai on mahdotonta, on ko. lajien lajiryhmiä ja koko *Marklissus* Reitt. -alasukua varten laadittu määrityskaavat. Suomesta tavatuiksi ilmoitetuista lajeista on tuholaisena pidetyn *C. napi* Gyll. sekä *C. thomsoni* Kolbe -lajien esiintyminen maassamme epävarmaa ja tarkistusta vaativaa. Kaikkiaan on Suomesta ilmoitettu 30 ristikukkaisilla kasveilla elävää *Ceuthorrhynchus*-lajia. Viljellyillä ristikukkaisilla on tavattu 14 lajia, joista 9 lajin elintavat ja ravintokasvivaatimukset ovat niin heikosti tunnettuja tai kokonaan tuntemattomia, että niiden selvittämistä pidetään tarpeellisena. Lajien joukossa on kaksi faunallemme uutta. Ristikukkaisilla elävien fennoskandisten lajien ravintokasviluettelo sisältyy kirjoitukseen.

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[1] Nyk. osoite: Alkutie 66 A, 00660 Helsinki 66

ANNALES AGRICULTURAE FENNIAE, VOL. 15: 81—85 (1976)

Seria ANIMALIA NOCENTIA N. 81 — Sarja TUHOELÄIMET n:o 81

"PEST IN FIRST" AND "NATURAL INFESTATION" METHODS IN THE CONTROL OF TETRANYCHUS URTICAE KOCH WITH PHYTOSEIULUS PERSIMILIS ATHIAS-HENRIOT ON GLASSHOUSE CUCUMBERS

MARTTI MARKKULA and KATRI TIITTANEN

MARKKULA, M. & TIITTANEN, K. 1976. **"Pest in first" and "natural infestation" methods in the control of Tetranychus urticæ Koch with Phytoseiulus persimilis Athias-Henriot on glasshouse cucumbers.** Ann. Agric. Fenn. 15: 81—85. (Agric. Res. Centre, Inst. Pest Inv., SF-01300 Vantaa 30, Finland).

The effectiveness and expenses incurred in two different approaches to the control of the two-spotted spider mite (*Tetranychus urticae*) with the predatory mite, *Phytoseiulus persimilis*, i.e. the "natural infestation" and "pest in first" methods, were evaluated in a commercial cucumber cultivation. Both methods gave equally good results. The proportion of spider mites to predatory mites was quite well balanced throughout the whole growing season, from the beginning of March to late September, and the spider mites did not cause any reduction of yield.

The "pest in first" method required moor work than the "natural infestation" method. It also required more spider mites. The "pest in first" method proved more expensive, and is not recommended to cucumber growers.

Index words: biological control, *Tetranychus urticae*, *Phytoseiulus persimilis*, "pest in first" method, "natural infestation" method, glasshouse cucumber, costs, effectiveness.

Since 1970 Finnish cucumber growers have been able to control the two-spotted spider mite (*Tetranychus urticae* Koch) biologically. In that year Kemira Ltd started production and sale of predatory mites (*Phytoseiulus persimilis* Athias-Henriot). There were about 500 cucumber growers in Finland at that time, 22 % whom adopted biological control the very first year. The control method recommended for growers was developed at the Department of Pest Investigation in the years 1966—1969. It was based on the natural infestation principle. The results gained during the first growing season, using the "natural infestation" method, were very positive (MARKKULA et al. 1972). After this the number of growers using biological control started to rise. In 1974 and 1975 about 70 % of growers introduced predatory mites in their cucumber cultures.

A method of controlling spider mites biologically has been developed at the Glasshouse Crops Research Institute (Littlehampton, Great Britain) under the leadership of Dr. N. W. Hussey. In this method the plants are first evenly infested with spider mites and then the predators are introduced. This method is called the "pest in first technique", and it has given very good results (e.g. BURGES 1974, GOULD et al. 1969, HUSSEY et al. 1965). It is applied in approximately half the cucumber cultivations in Great Britain (BURGES 1974). At a meeting of the European Study Group on Integrated Control in Glasshouses (OILB), it was agreed that experiments would be arranged in Finland and France to compare the natural infestation and "pest in first" methods.

Material and methods

Experiments were carried out in two 1000 m^3 glasshouses on a commercial cucumber cultivation. In late February 630 cucumbers of the variety Arla were planted in both glasshouses to 9 rows.

The pest in first method was evaluated in accordance to the instructions given by Dr. N. W. Hussey in a letter of November 28, 1973. Eight days after planting, 20 female spider mites were placed on each plant, 12 600 mites altogether. As the damage index was 0.4 (see HUSSEY and PARR 1963), two predatory mites were placed on every other plant, altogether 630 mites. Spider mites were transferred with a brush from mass cultures onto bean leaves, which were subsequently placed on cucumber plants. Predatory mites were transferred directly onto the cucumbers with a brush.

The first signs of natural infestation in the other glasshouse were discovered on March 10. On March 15 and 18, one predatory mite to 10 spider mites were placed on 52 seedlings, a total of 450 predatory mites. The plants was inspected every week. Five times during the growing season ~~spider~~ PREDATORY mites were transferred with brush to places where they were too sparse.

The number of predatory and spider mites was counted once a week in both glasshouses. One leaf was choosen from the middle of six plants in each row, and the number of mites was counted over an area of 25 cm^2 on each leaf. Every week a total of 1350 cm^2 from 54 leaves were checked for mites in each glasshouse.

Results

Both methods brought a complete result in the control of spider mites. The damage was quite small and below the economic thereshold

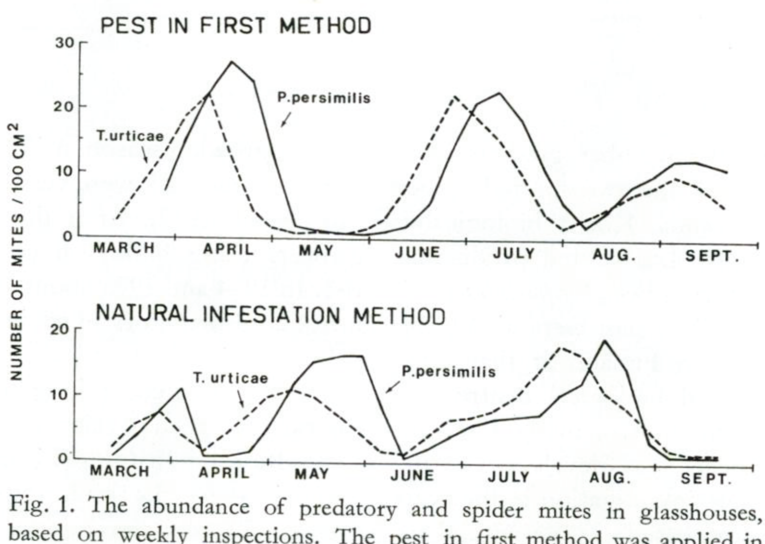

Fig. 1. The abundance of predatory and spider mites in glasshouses, based on weekly inspections. The pest in first method was applied in one and the natural infestation method in the other glasshouse.

Table 1. Expenses incurred in the pest in first and natural infestation methods in two glasshouses, 1000 m^3 of size. Results from a comparative experiment. In the pest in first method, 20 spider mite females were placed on each plant and two predatory mites on every other plant. In the natural infestation method one predatory mite was placed to 10 spider mites.

		Pest in first method		Natural infestation method		
		Working hours	Fmk		Working hours	Fmk
Number of spider mites	12600		?	—		—
Sampling and placing of spider mites		55	440	—		—
Number of predatory mites	630		177	450		126
Placing of predatory mites		5	40		4	32
Inspection and transfer of predatory mites		—	—		5	40
		60	657		9	198

in both glasshouses. The proportion of spider mites to predatory mites was quite well balanced throughout the whole growing season, from the beginning of March to late September (Fig. 1). Fluctuations in abundance were slightly greater in the glasshouse where the pest in first method was used.

In applying the pest in first method, 51 working hours were spent collecting spider mite from mass cultures, 4 hours placing them on plants, and 5 hours introducing predatory mites onto plants.

The natural infestation method required 4 working hours for introducing predatory mites onto plants at the beginning of the infestation. Altogether 5 hours were spent on weekly inspections and transferring the predatory mites.

The pest in first method required more predatory mites, 650, than the natural infestation method, 450.

In this study the pest in first method was considerably more expensive than the natural infestation method (Table 1).

DISCUSSION

It has been thought that the pest in first method is more advantageous than the natural infestation method because the number of predatory mites required is smaller and because it is not necessary to add and transfer mites (e.g. Burges 1974). Up to the present there is no record how long it does take to infest the plants artificially with spider mites, and what the expenses involved are. Besides the costs of introducing the spider mite, the grower has to pay for mass-producing the mites. In the present study, spider mites were placed on the plants strictly according to the instructions given by Dr. N. W. Hussey, and the work thus took more time than it would in practice. Picking out 20 spider mite females from the mass cultures was especially laborious.

When we informed Dr. Hussey on our preliminary results, he replied (in a letter of March 19, 1975) that as good results are obtained in practice if 1 to 50 spider mites are placed per plant instead of the exact 20 females, and in this case placing mites on 200 plants would take only one hour. In practice, infesting of 630 plants with mites would thus take only an ample 3 hours.

Similarly, the labour costs involved in the natural infestation method are clearly lower in practice than in the present study. In practice one predatory mite is placed on plants against 5 to 10 spider mites. The grower only estimate the number of spider mites, he does not count them.

If the predators are placed on plants immediately the first signs of damage appear, a smaller number of them is needed in the natural infestation method than in the pest in first method. Early introduction of predatory mites is the most important premise for succesful control by the natural infestation method. Inspections and transfers of mites can be carried out conveniently at the same time as other cultivation practices, for instance pruning or harvesting. No extra visits to the glasshouses are needed, and the time-consuming job of inspecting plants is unnecessary.

Balance in numbers of mites on plants is maintained by detaching leaves from plants with excess of predatory mites and transferring them to places in glasshouses where the predatory mites are too scanty. In the same way leaves with spider mites can be transferred for the predatory mites, where they are needed.

On the basis of the present experiment and previous experience, the authors estimate how long it would take to introduce the mites on plants and to transfer them on a practical scale. The pest in first method would perhaps require no more than 3 hours for placing the spider mites instead of the 55 hours in the present experiment. Similarly the natural infestation method would require only two hours for placing the predatory mites, and three hours for subsequent transfers.

Applying the pest in first method in practice would cost a total of 245 Fmk, and the natural infestation method 164 Fmk per 1000 m^3.

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Martti Markkula and Katri Tiittanen
Agricultural Research Centre
Institute of Pest Investigation
SF-01300 Vantaa 30, Finland

SELOSTUS

Vihannespunkin biologisen torjunnan tulokset ja kustannukset

MARTTI MARKKULA ja KATRI TIITTANEN

Maatalouden tutkimuskeskus

Englannissa on kehitetty vihannespunkin biologiseen torjuntaan »tuholainen ensin» menetelmä, jota käytetään siellä yleisesti. Sen mukaan kurkkukasvustoon levitetään ensin vihannespunkkeja ja vasta määräajan kuluttua petopunkkeja. Suomessa on vuodesta 1970 lähtien käytetty Tuhoeläintutkimuslaitoksella kehitettyä »luonnollisen saastunnan» menetelmää, jossa petopunkit sijoitetaan kasvustoon heti, kun ensimmäiset vihannespunkin vioitusjäljet ilmaantuvat.

Tässä tutkimuksessa vertailtiin näiden menetelmien tuloksia ja kustannuksia kahdella 1 000 m²:n suuruisella kurkkuviljelyksellä. Kummallakin menetelmällä saatiin täydellinen tulos, sillä vihannespunkkien määrä ei noussut tuhoa tuottavaksi. Tuholainen ensin tekniikka vaati kuitenkin suuremman työmäärän luonnollisen saastunnan menetelmään verrattuna ja sen käytössä tarvittiin myös enemmän petopunkkeja.

Englannissa kehitetty menetelmä osoittautui tuloksiltaan Suomessa kehitetyn veroiseksi, mutta selvästi kalliimmaksi, joten sitä ei suositella kurkun viljelijöille.

ANNALES AGRICULTURAE FENNIAE, VOL. 15: 86—88 (1976)
Seria ANIMALIA NOCENTIA N. 82 — Sarja TUHOELÄIMET n:o 82

MORTALITY OF APHIDOLETES APHIDIMYZA ROND. (DIPT., ITONIDIDAE) LARVAE TREATED WITH ACARICIDES

MARTTI MARKKULA and KATRI TIITTANEN

MARKKULA, M. & TIITTANEN, K. 1976. **Mortality of Aphidoletes aphidimyza Rond. (Dipt., Itonididae) larvae treated with acaricides.** Ann. Agric. Fenn. 15: 86—88. (Agric. Res. Centre, Inst. Pest. Inv., SF-01300 Vantaa 30, Finland).

The effect of acaricides on the larvae of *Aphidoletes aphidimyza* Rond., a predator of aphids, was studied. Applying the dosages normally recommended, chlorobenzilate, dicofol, dienchlor, dinobuton, formetanate and quinomethionate were harmless to *Aphidoletes* larvae. Thus these acaricides can be used to control the two-spotted spider mites (*Tetranychus urticae* Koch) in glasshouses where aphids are controlled biologically by *Aphidoletes* larvae.

Index words: *Aphidoletes aphidimyza, Itonididae,* larval mortality chlorobenzilate, dicofol, dienochlor, dinobuton, formetanate, quionomethionate acaricides.

The efficiency of the Itonidid midge, *Aphidoletes aphidimyza* Rond. in aphid control has been under going evaluation at the Institute of Pest Investigation of the Agricultural Research Centre since 1973. The first practical tests already showed that damage caused to roses by the rose aphid *Macrosiphum rosae* (L.) can be prevented by instroducing *Aphidoletes* pupae into the glasshouses (MARKKULA 1973).

The two-spotted spider mite (*Tetranychus urticae* Koch) usually occurs in glasshouses simultaneously with aphids. These spider mites must be controlled by acaricides, which are often considered harmless to natural enemies. However many studies have revealed differences in the effects of acaricides: they clearly can be harmful to natural enemies (e.g. BINNS et al. 1971, COLBURN and ASQUITH 1971, CROFT and JEPPSON 1970, STENSETH 1973, 1975). The effects of acaricides on *Aphidoletes* larvae were unknown and laboratory tests were therefore conducted to find out how the commonly used acaricides affect these larvae.

Material and methods

The experiments were carried out in laboratory in autumn 1973 and spring 1975. A wetted filter paper was placed on the bottom of a petri dish (diameter 90 mm, height 40 mm).

A leaf of green pepper infested with green peach aphids and 25 *Aphidoletes* larvae of the second or third instar were then placed in the dish. Four dishes (altogether 100 larvae) were sprayed with each acaricide in a laboratory spraying apparatus (the Potter tower). The amount of spray per one dish was 1.1 ml. After treatment, the dishes were covered with thin gauze. Mortality among the larvae was checked two days after the treatment. Four replica tests were carried out.

The acaricides and the normally recommended dosages of them tested were as follows:

- 20 % chlorobenzilate, liquid, Akar 20 1 g/l
- 18.5 % dicofol, w.p., Kelthane W 1.5 g/l
- 50 % dienochlor, w.p., Pentac-50-Plant 1 g/l
- 50 % dinobuton, w.p., Acrex 50 1 g/l
- 25 % + 50 % formetanate + chlordimeform, w.p., Fundal Forte 0.75 g/l
- 25 % quinomethionate, w.p., Morestan 0.5 g/l

Results

Aphidoletes aphidimyza larvae stood up well all the acaricides tested: chlorobenzilate, dicofol, dienochlor, dinobuton, formetanate and quinomentionate (Table 1). Thus *Tetranychus urticae* can be controlled chemically by acaricides in glasshouses where aphids are controlled biologically by *Aphidoletes*.

Table 1. Mortality of *Aphidoletes aphidimyza* larvae treated with acaricides.

	Mortality two days after treatment per cent				
	Replicas				
	I	II	III	IV	Mean
Chlorobenzilate, Akar 20	5	3	5	6	5
Dicofol, Kelthane W	1	2	0	4	2
Dienochlor, Pentac-50-Plant	3	5	1	9	5
Dinobuton, Acrex 50	7	7	6	8	7
Formetanate + chlordimeform, Fundal forte	17	7	1	14	10
Quinomethionate, Morestan	2	3	0	3	2
Untreated control	1	3	2	10	4

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Martti Markkula and Katri Tiittanen
Agricultural Research Centre
Institute of Pest Investigation
SF-01300 Vantaa 30, Finland

SELOSTUS

Punkkimyrkkyjen haitallisuus kirvasääsken toukille

Martti Markkula ja Katri Tiittanen

Maatalouden tutkimuskeskus

Äkämäsääskiin kuuluva petohyönteinen, kirvasääski on Tuhoeläintutkimuslaitoksen kokeissa osoittautunut tehokkaaksi torjuntaeliöksi. Hyviä tuloksia on saatu ruusun ja paprikan kirvojen torjunnassa.

Kasvihuoneissa on varsin usein samanaikaisesti lehtikirvojen kanssa vihannespunkkeja, joiden torjuntaan käytetään punkkimyrkkyjä. Sen tähden pidettiin tarpeellisena tutkia tappavatko yleisimmät punkkimyrkyt kirvasääsken toukkia.

Käytetyt akarisidit, dienoklori, dikofoli, dinobutoni, formetanaatti, kinometionaatti ja klorbentsilaatti olivat kirvasääsken toukille haitattomia. Näin ollen vihannespunkin torjuntaan voidaan käyttää näitä punkkimyrkkyjä kasvihuoneissa, joissa lehtikirvat torjutaan kirvasääsken toukkien avulla.

ANNALES AHRICULTURAE FENNIAE, VOL. 15: 89—96 (1976)

Seria ANIMALIA NOCENTIA N. 83 — Sarja TUHOELÄIMET n:o 83

SCOTS PINE SEED DEPREDATION BY SMALL MAMMALS, AS REVEALED BY RADIOACTIVE TAGGING OF THE SEEDS

ARVO MYLLYMÄKI and ARJA PAASIKALLIO

MYLLYMÄKI, A. & PAASIKALLIO, A. 1976. **Scots pine seed depredation by small mammals, as revealed by radioactive tagging of the seeds.** Ann. Agric. Fenn. 15: 89—96. (Agric. Res. Centre, Inst. Pest Inv., SF-01300 Vantaa 30, Finland).

Depredation of Scots pine (*Pinus silvestris* L.) seed by small mammals was studied by labelling exposed seeds with radioisotopes I 131 and P 32. The experiments were conducted in a geographical area (Central Finland) where renewing pine stands by seeding is the usual practice and on habitats approximating typical seeding terrain. The local small mammal fauna consisted of three dominant species, *Microtus agrestis* (L.), *Clethrionomys glareolus* (Schreb.) and *Sorex araneus* L., which made up more than 98 % of a pooled 4-year catch. In this particular experiments two species, *M. agrestis* and *S. araneus*, were shown to be seed depredators, but the main emphasis was on depredation by *Sorex*. For this reason and because there was an immediate response by small mammals to the seeds exposed, there is little chance that any season or year would be safe for seeding programmes. When considering means of combating seed destruction, the authors emphasize the prospects of applying prompt acting chemicals (conventional rodenticides, systemic insecticides or, maybe, systemic repellents) directly onto the seed to be distributed. Most alternatives reported or proposed in the literature are rather unreliable or far too theoretical to serve as a short-term solution.

Index words: seed depredation, small mammals, *Pinus silvestris*, radioactive labelling.

INTRODUCTION

In an earlier paper (MYLLYMÄKI and PAASIKALLIO 1972) the authors demonstrated a liking in North-European small mammals for seeking out and depredating conifer seed. This pilot experiment led us to suggest that not only several rodent species but also insectivorous shrews, especially *Sorex araneus* L., were major seed depredators in forest regeneration areas. However, our principal aim at that time was to demonstrate a simple method for studying seed depredation, i.e., by means of tagging the seed with radioactive material. The experiment set-up was not typical of the conditions under which seed depredation actually occurs. A set of new experiments reported in this paper aimed at relating earlier findings more closely to practical forestry problems. Subsequently, our new experiments differ from the earlier ones, e.g., in the following aspects:

— Scots pine (*Pinus silvestris* L.) seed was used instead of Norwegian spruce (*Picea abies* (L.) Karst.), because usually only pine stands are renewed by sowing,
— the seeds were exposed by sowing them in uncovered spots of soil, as they are in practice (special feeding stations were used earlier), and
— the experiments were conducted in an area where seeding is commonly practised, and on habitats approximating at least to typical seeding areas for pine, and where there was a small mammal fauna more or less typical for such areas.

As in our earlier work, the exposed seed was tagged with radioisotopes (I 131 and P 32, this time) to trace the depredators. No attempt was made to analyse the "death rate" of the exposed seed as a whole. The same method, using different isotopes, has been used by some American workers, LAWRENCE and REDISKE (1960): Sc 46, RADVANYI (1966, 1970, 1971): Sc 46, Zn 65, Co 60, and BLACK (1969): Sc 46. Our choice of isotopes was based on the short half-lives and subsequent minimal hazards involved using these two taggers as well as on their relatively low price.

Although the field work did not involve any control experiments, we are taking the liberty of discussing briefly the chances of preventing seed destruction. This can perhaps be justified, firstly, because very little attention has been paid to this problem in Northern Europe and, secondly, because ever-increasing planting costs are awakening general interest in the development and use of direct seeding procedures.

MATERIAL AND METHODS

Study area, habitats and the small mammal fauna.

The experiments were conducted in Korpilahti, Central Finland (about 62°03′N and 25°30′ E), in September 1972. As seen in Fig. 1, this vicinity is within the area where direct seeding is generally practised. The experimental plots were not, however, situated on actual seeding areas but in pine seed orchards owned by the State Forestry Board. Apart from the fact that seed orchards are generally established on soil better than average for pine, the habitat characteristics presumably did not differ essentially from cleared areas of forest ground in general. Depending on the age of the seed orchard, and on its recent management, the vegetation was in various successive stages in different areas. As a rule, the grasses (e.g., *Calamagrostis* spp., *Deschampsia flexuosa*, *Agrostis* sp., etc.) and forbs (such as *Chamaenerium angustifolium*) and/or deciduous shrubs were luxuriant enough to supply cover and food for several small mammal species.

Since all seed orchards have been subject to regular surveillance of small mammal numbers since 1969, the long-term figures given in Table 1 probably illustrate better the general characteristics of the small mammal fauna than catch numbers for this particular experiment do. On the basis of these figures, the seeds are generally exposed to at least three species of small mammals, *Microtus agrestis* (L.) *Clethrionomys glareolus* (Schreb.) and *Sorex araneus* L., these species made up more than 98 % of the whole small mammal catch during the four years referred to. Moreover, during periodic lows in *Microtus* and *Clethrionomys*, the common shrew makes up the bulk of the catch and its numbers never fall as low as those of the other two dominant species. Complete absence of *Apodemus flavicollis*

Table 1. Actual and percentage distribution of the species composition of the yearly SQ catches in seed orchards on forest ground, in and surrounding the area where the seed experiments were performed.

Species	1969 n	1969 %	1970 n	1970 %	1971 n	1971 %	1972 n	1972 %	Together n	Together %
Microtus agrestis (L.)	103	74.6	6	16.2	33	14.6	456	69.0	598	56.3
Clethrionomys glareolus (Schreb.)	10	7.2	1	2.7	19	8.4	121	18.3	151	14.2
Arvicola terrestris (L.)	1	0.7	4	10.8	—	—	1	0.2	6	0.6
Mus musculus L., *Micromys minutus* (Pall.)	—	—	—	—	1	0.4	3	0.5	4	0.4
Sorex araneus L.	23	16.7	26	70.3	171	75.7	76	11.5	296	27.9
Neomys fodiens (Pennant)	1	0.7	—	—	2	0.9	4	0.6	7	0.7
Total catch	138	(99.9)	37	(100.0)	226	(100.0)	661	(100.1)	1 062	(100.1)

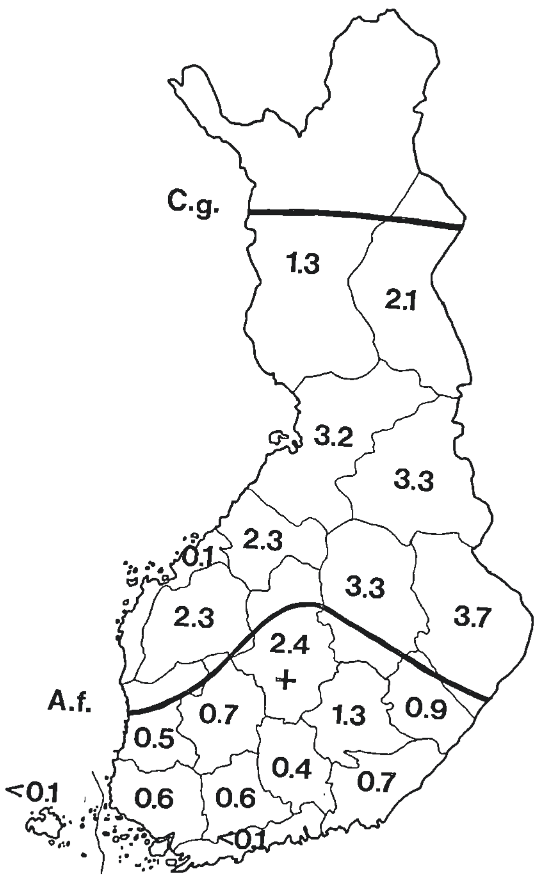

Fig. 1. Scots pine seeding areas in Finland, 1972, according to the administrative districts of private forestry, and the approximate northern borders of the geographical ranges of two prospective seed depredators, *Apodemus flavicollis* (A. f.) and *Clethrionomys glareolus* (C. g.). Probably the most important seed depredator, *Sorex araneus*, is distributed all over the country, as is *Microtus agrestis*, the dominant rodent species on cleared reforestation areas. The location of the experiments reported here is marked with a cross. Figures indicate sledin areas in 1000 ha.

(Melch.), and pronounced scarcity of all Murids, was a major difference vis à vis the conditions described by MYLLYMÄKI and PAASIKALLIO (1972).

Seed labelling and exposing

The radioactive seed baits were prepared and distributed in two stages with one week's interval. On the first occasion, 1 900 pine seeds, in lots of 100, were soaked overnight in small plastic tubes each containing 1 ml carrier-free aqueous solution of sodium iodide with 100 μCi I 131. At the second treatment, half of the 2 000 seeds treated were soaked in the same amount of the same solution, now containing 54 μCi I 131 in 1 ml (half-life of I 131 is 8.4 days), and the other half in a neutral carrier-free sodium orthophosphate solution with 70 μCi P 32 in 1 ml (half-life 14.3 days). In the morning, the seeds were dried on a sheet of blotting paper, and then distributed on the terrain.

A separate laboratory experiment was made to check distribution of the activity counts of individual seeds and to discover what proportion of the activity was caught by the seed coat. The isotopes used were P 32 and Se 75 (direct observations on the penetration of I 131 are thus lacking), and both pine and spruce seeds were investigated. The results of this methodological check experiment were as follows:

Species	Isotope	Activity counts (cpm) mean ± S.D.	Per cent of the activity in the endosperm
Pine	P 32	185 ± 74 (n = 100)	18 % (n = 39)
»	Se 75	507 ± 154 (n = 80)	55 % (n = 30)
Spruce	P 32	109 ± 61 (n = 30)	43 % (n = 30)
»	Se 75	467 ± 152 (n = 100)	65 % (n = 30)

Even if the difference between the maximum and minimum values was about 4-fold, variation in the take of labels by individual seeds was within reasonable limits. Absorption of the isotopes seemingly depends on the tree species and, also, different isotopes (= labelled compounds) evidently have different rates of penetrating the seed coat. The subsequent labelling of the depredator thus probably depends on the animal's feeding behaviour, i.e., whether it dehusks the seed or also devours the coat. The practical consequences of this kind of error are not, however, serious in such a qualitatively oriented experiment as that reported here.

The tagged seeds were sown according to instructions given by the local forest technician, Mr. V. Berg: a sowing plot, about 15 × 25 cm in size, was uncovered of field vegetation and detritus, furrowed by means of a stick, the seeds sprinkled in the furrows, and covered lightly with earth. Two sowing plots, i.e. 2 × 100 seeds, were placed inside each of the trapping quadrates. At the first application (Sept. 5), four of the quadrates were provided with special feeder-boxes with 100 seeds in each. On the second occasion (Sept. 12), I 131 and P 32 labelled seeds were placed on separate trapping quadrates, all at least 100 metres apart from each other.

Trapping procedure and handling the catch.

Trapping was conducted according to the SQM procedure described by Myllymäki et al. (1971), i.e., 15 × 15 metres small quadrates with three traps at each corner were run for two days. Subsequent inspection of the specimens caught followed the "Nordmus routines" (Myllymäki 1972). Since the small mammals responded immediately to the exposed seed (practically all seeds offered in the feeders disappeared during the first night and all the seeding plots were completely turned up by the very next morning), the traps were set immediately the day after exposing the seed.

Radioiodine in the animals was measured by a multichannel gammaspectrometer (LP 4840 Nokia) with a 2 × 2" plane crystal. To minimize background radiation, the animals were placed in a lead chamber during measurement. Radiophosphorus was detected by means of a portable GM counter (RD-11 Wallac). The dose level of radioiodine both in seed and in tagged animals was beneath the sensitivity range of the GM counter. Subsequently, it was possible to separate the two markers even in the same animal. As a check the thyroids of the iodine-tagged animals were removed; practically all the iodine absorbed collects in the thyroids.

RESULTS AND DISCUSSION

Depredators and their feeding capacity.

Pooled catch numbers for both treatments are given in Table 2. No more than 14.2 % of all animals caught gave a positive response in radioactivity measurements. In agreement with our earlier findings (Myllymäki and Paasikallio 1972), the most abundant species, *Microtus agrestis*, showed little interest in conifer seed and, unexpectedly, there was no positive response among *Clethrionomys glareo-*

Table 2. Total catch numbers and proportion of labelled individuals in the catch. Pooled results of 20 small quadrats (SQ), in each of which I 131 and P 32 labelled pine seed were exposed one day before setting the traps.

Species	Total catch	Number of radioactive individuals I 131	P 32	together	per cent
Microtus agrestis	74	6	1	7	9.5
Clethrionomys glareolus	7	—	—	—	—
Sorex araneus	23	6*	4*	8	34.8
Neomys fodiens	1	—	—	—	—
Total	105	12	4	15	14.3

* 2 individuals showed both I 131 and P 32 response

lus. On the other hand, our suspicions that *Sorex araneus* is a major seed depredator were confirmed.

Of special interest were the two individuals of *Sorex* that were labelled by both markers, I 131 and P 32. One of the animals had had only one day and the other two days to pass from the plot where they were first labelled to the trapping quadrate. Assuming that these were random movements, the observations probably indicate (1) a nomadic pattern of movement and great agility in this species population, which in turn, presumably explains the relatively high proportion of unlabelled *Sorex* individuals in the catch. Alternative explanations could be, e.g., (2) fierce competition over the few (in relation to the animals' feeding capacity) seeds exposed, or (3) a bias introduced by poor labelling of the endosperm and, hence, the depredator. As far as the second alternative is concerned there is evidence in the literature of this leaning of *Sorex* for conifer seed, even in preference to animal food (BUCKNER, pers. comm. according to RADVANYI 1973, HEIKKILÄ 1974). KANGUR (1954, ref. by RADVANYI 1973) has shown in experiments that an American counterpart of our common shrew consumed on average 180 white spruce seeds daily (our pine and spruce seeds, 3 to 4 mm in length, are only slightly longer than white spruce seeds), which in practice means that a single animal was capable of devouring all seeds exposed inside one trapping quadrate within one or two days. No wonder that there was a short of labelled seeds among all the animals trapped. Some support for the third alternative can be found in the distribution of activity counts among animals responding positively, as represented in Table 3: low rank counts are rather frequent. However, since more seed coat remnants were found in the stomach contents of shrews than rodents (RADVANYI, in litt.), this source of error probably only plays a major role where rodents are concerned and, as referred to

Table 3. Distribution of radioactivity counts of individual small mammals showing positive response to I 131 and/or P 32. The background value for iodine was about 70 cpm (lowest accepted count 148 cpm), that for phosphorus about 2 cps (lowest accepted count 4 cps).

Tracer I 131 (cpm)	Numbers Microtus	Sorex	Tracer P 32 (cps)	Numbers Microtus	Sorex
<200 000	2	—	<100	1	—
<100 000	—	1	< 50	—	1
< 10 000	—	5	≤ 10	—	3
< 1 000	4	—			
Total n	6	6	Total n	1	4

earlier, especially when the tagger is P 32.

Limited as our material is, it clearly indicates that shrews play a more important role as seed depredators in Northern Europe than is generally assumed that they do in North America (RADVANYI 1970, 1971). The difference is evidently due to the scarcity of superior competitors, first of all species of the *Apodemus*, the ecological counterparts of the North-American *Peromyscus*. According to SIIVONEN (1974), our study area lies within the geographical range of *A. flavicollis*, but the species has never been caught on the cleared reforestation areas in Central Finland, neither is it frequent on corresponding habitats in other parts of Southern Finland. Furthermore, competition on the part of *Clethrionomys* does not seem to be severe for *Sorex*. In this respect, the situation in Sweden and Norway may be rather different (cf. HANSSON 1975, CHRISTIANSEN 1975).

Our experimental plan did not aim at comparing seed depredation by small mammals with that of other depredators (birds, insects, etc.). However, the extreme rapidity with which the small mammals investigated all seeding spots thoroughly renders it questionable whether any essential portion of the seeds is more available to other depredators. In the case of our study area, very few granivorous birds were observed around the seeding plots. As stated by several American authors (e.g., ABBOTT 1961, RADVANYI 1973) and calculated theoretically by HANSSON (1975) for Swedish conditions, the seed devouring capacity of mammalian depredators alone generally exceeds any amounts of conifer seed that it is feasible to sow.

Chances of preventing conifer seed depredation.

Nearly all experimental work on the control of seed depredators has been conducted in the U.S.A. or Canada (e.g., RADVANYI 1972, PASSOF 1974). There are two conventional approaches, i.e., poisoning the animals directly and application of repellent substances to the seeds. In fact, the borderline between these two methods is rather obscure: highly poisonous chemicals, such as endrin, are called repellents when applied directly to the seed.

Theoretically, finding an attractive bait for the seed-eaters should be much easier than it is in the case of strictly herbivorous voles (MYLLYMÄKI 1975a, b). The bait could, perhaps, be the conifer seed itself. Excess use of poisoned seed would hardly increase seeding costs more than an additional application of a separate poison bait and, at the same, one could avoid possible failures due to inferior palatability of other bait materials. Because the animals are usually able to distinguish poisoned bait from the same material unpoisoned, it would be necessary to treat all the seeds exposed. This in turn implies that the active ingredient should not influence negatively the germination of the seed. Conversely, it does not matter if the chemical applied has repellent properties; it protects the seed then, anyway. Another important property for prospective poison would be prompt action (e.g., anticoagulants and chemosterilants are, therefore, out of the question. Among rodenticides presently known there are some possible applicants such as crimidin or the Russian rodenticide "Glyftor" (chemically related to the fluoracetamide), but the solution could as well be found among systemic insecticides.

The latter alternative is worth more detailed consideration. Much of the failure in using an endrin-arasan-latex combination, the repellent substance R-55 advocated by RADVANYI (1972), or other repellents (cf. HANSSON 1975), presumably depends on the rodents' ability to dehusk the seed in the way the Microtine voles remove the outermost layer of bark (cf. MYLLYMÄKI 1975a, b). Therefore, to secure rapid action on the rodent, the poison (or repellent) applied to the seeds should be absorbed into the endosperm, as systemic chemicals are more likely to do than conventional rodenticides.

It might be worth warning against missinterpretation of the suggestions above: we by no means advocate a large-scale application of poisoned seed before all pertinent details, concerning both the efficacy and the risks involved have been carefully examined (in most countries, regulations on the registration and use od plant protection chemicals already provide a safeguard that these aspects are considered). We only want to stress that a prompt solution to the problem would most likely be found along these conventional lines. Such alternatives (cf. HANSSON 1975) as manipulating the habitats so that they are unsuitable for the depredators, "deodoration" of the seed, or utilization of the pheromones as a part of the control programme (cf. CHRISTIANSEN and DØVING 1975) are, for the time being, interesting research objectives but can hardly be considered solutions for the near future.

Some authors (RADVANYI 1972, HANSSON 1975) suggest ample timing of seeding (or broadcasting of seed) as a partial solution to the seed depredation problem. Thus, when the seeds are broadcast on snow, they are practically inaccessible to the small mammals that generally move under the snow cover (RADVANYI 1970). On the other hand, there is little, pratically no, evidence that small mammals would leave conifer seed untouched solely due to simultaneous availability of animal food, or that periodic lows of rodent numbers would guarantee safe seeding. HANSSON (1975) presumably underrates the role of shrews in high northern latitudes, where the *Apodemus* species are absent and voles (*Microtus*, *Clethrionomys*) undergo drastic periodic fluctuations in numbers. We cannot find any firm basis for advocating that years of rodent scarcity are safe for seeding programmes because numbers of *Sorex* do not fluctuate as violently and according to the same pattern as rodents.

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MS received 6 February 1976

Arvo Myllymäki
Agricultural Research Centre
Institute of Pest Investigation
SF-01300 Vantaa 30, Finland

Arja Paasikallio
Agricultural Research Centre
Isotope Laboratory
SF-01300 Vantaa 30, Finland

SELOSTUS

Pikkunisäkkäät männyn kylvöalojen siementuholaisina

ARVO MYLLYMÄKI ja ARJA PAASIKALLIO

Maatalouden tutkimuskeskus

Valtion metsähallinnon siemenviljelyksillä Keski-Suomessa tutkittiin pikkunisäkkäiden vaikutusta siemenkatoon männyn kylvöaloilla. Kokeiden suorituspaikat olivat normaaleja kylvöaloja keskimäärin rehevämpiä, mutta koealojen pikkunisäkäslajisto ei otaksuttavasti poikennut olennaisesti paljaaksihakkuualojen normaalista lajistosta. Kolme lajia, peltomyyrä, metsämyyrä ja metsäpäästäinen, muodostivat yli 98 % koealoja vastaavilta biotoopeilta samalla seudulla neljän vuoden aikana saadusta pikkunisäkässaaliista (taulukko 1).

Pikkunisäkkäiden taipumusta etsiä ja syödä maahan normaaliin tapaan kylvettyjä männynsiemeniä selvitettiin merkitsemällä siemenet radioaktiivisella jodilla (J 131) tai fosforilla (P 32). Siemeniä syöneet eläimet voitiin tämän jälkeen tunnistaa mittaamalla syöttöpaikoilta pyydystettyjen yksilöiden radioaktiivisuus. Pyynti- ja mittaustulokset sekä radioaktiivisuuslukemien jakaantuminen on esitetty taulukoissa 2 ja 3. Tuloksista voidaan päätellä, että koealueen lajistosta metsäpäästäinen on mitä ilmeisimmin pahin siemen-tuholainen. Koealueilla ei esiintynyt siemensyöjänä todennäköisesti päästäistä tehokkaampaa metsähiirtä, eikä sitä yleensäkään sanottavasti tavattane paljaaksihakatulla metsämaalla siinä osassa maata, missä mäntymetsän uudistamiseen käytetään yleisesti kylvöä (kuva 1).

Mahdollisia torjuntakeinoja pohtiessaan kirjoittajat pitävät siementen käsittelyä jollain siemenvalkuaiseen imeytyvällä torjunta-aineella tai karkoitteella todennäköisimpänä lähitulevaisuuden ratkaisumallina. Torjuntaa tuskin voidaan perustaa pelkästään kylvöajan valintaan, sillä metsäpäästäisen jyrsijöitä vähäisempi runsaudenvaihtelu tuskin milloinkaan johtaa tilanteeseen, missä siemeniä syöviä pikkunisäkkäitä olisi niin vähän, että minkäänlaisia siementuhoja ei voitaisi odottaa. Muut torjuntamahdollisuudet, kuten esim. pikkunisäkkäitä houkuttelevien aineiden poisto siemenistä tai peittäminen muilla tuoksuilla, ns. feromonien hyväksikäyttö jne. ovat toistaiseksi vain teoreettisia ajatusrakennelmia.

ANNALES AGRICULTURAE FENNIAE, VOL. 15: 97—100 (1976)

Seria ANIMALIA NOCENTIA N. 84 — Sarja TUHOELÄIMET n:o 84

ABERRANT SPERMATOGENESIS IN THE LEAFHOPPER MACROSTELES LAEVIS (RIB.), INFECTED BY THE ASTER YELLOWS AGENT

MIKKO RAATIKAINEN, OLLI HALKKA, LIISA HALKKA, RIITTA HOVINEN, and ARJA VASARAINEN

RAATIKAINEN, M., HALKKA, O., HALKKA, L., HOVINEN, R. & VASARAINEN, A. 1976. **Aberrant spermatogenesis in the leafhopper Macrosteles laevis (Rib.), infected by the aster yellows agent.** Ann. Agric. Fenn. 15: 97—100. (Dept. Biol., Univ. Jyväskylä, Finland)

Leafhoppers (*Macrosteles laevis* (Rib.)) reared on plants infected with the aster yellows agent (AYA) showed distinctly more disturbance at spermatogenesis than leafhoppers reared on healthy plants. The defects observed in the AYA-plant leafhoppers, which themselves obviously were infected by AYA, included pycnosis of interphase and prophase nuclei, chromosomal aberrations at metaphase, and deformation of sperm heads. The different testis cysts or sperm bundles were dissimilarly affected. It is considered highly probable that the defects are due to direct or indirect effects of AYA infection.

Index words: aster yellows agent, vector spermatogenesis, cytogenetic disturbance.

A Finnish type of the aster yellows agent (AYA) is able to infect graminaceous plants (MURTOMAA 1966). Leafhoppers belonging to the genus *Macrosteles* (Homoptera, Cicadellidae) are efficient vectors of this pathogen. The microbe in question belongs to the ill-defined group "mollicute-like organisms" (MLO), known to be always pathogenic to insect vectors (HIRUMI and MARAMOROSCH 1973, MARAMOROSCH 1974).

LITTAU and MARAMOROSCH (1960) have shown that AYA can cause changes in the nuclei of the fat body cells of *Macrosteles fascifrons*. AYA has been recovered from the ovary but not from the testes of *M. fascifrons*, but SINHA and CHIYKOWSKI (1967) point out that negative findings in the testes do not rule out the possibility that AYA exists in these tissues in undetected concentrations.

In a number of leafhopper species testicular disturbances of probable microbial aetiology have been reported (HALKKA and HALKKA 1969). Rickettsiae, a group not very distant from the MLO, are able to cause aberrant spermatogenesis in insects (HALKKA et al. 1970).

To investigate the effects of a plant MLO on the spermatogenesis of the vector, a number of young nymphs of *Macrosteles laevis* were placed on AYA-infected barley for acquisition feeding. A control group was reared on healthy barley. Both the infected and the healthy plants were sprayed with mevinphos ("Phosdrin") and dichlofluanid ("Euparen", "Elvaron") to control pests. At the time the experiment began, the plants were free from insecticide contamination.

Five males from the virotic plants ("AYA group") and nine from the healthy plants ("control group") were fixed in acetic alcohol. After Feulgen-staining *in toto* and sectioning at 15 micra, the specimens were checked for any abnormalities in spermatogenesis. Sections from each of the specimens were mounted on separate slides which were provided with random code numbers. Without the code, the slides were presented to three microscopists for checking.

Meiosis in the control group was not completely normal. Sporadic occurrence of oversized sperm heads and anaphase stickiness or bridges were noted by all three microscopists in two of the control group specimens. Systematic and extensive testicular damage, however, was not observed in any of the specimens from the control group.

In the AYA group, damage to the testis was very extensive in three of the specimens and a little milder in the remaining two. Disturbances included pycnosis, sperm deformation (Fig. 1) and aberrant numbers of chromosomes in some of the meiotic cysts.

In the normal karyotype, *M. laevis* has 8 pairs of autosomes and XO type gonosomes (Fig. 2). In the AYA group specimens, cells with both sub- and supranormal numbers of chromosomes were observed. In most of these cells, the metaphase plates or anaphase division figures of the first or second meiotic division were irregular and abnormal. Cytogenetically the most interesting observation is the first division metaphase cyst with 11 chromosomes (Fig. 3) in all the cells of which it was possible to determine the number of chromosomes. Most of these chromosomal formations appear to be bivalents, but in some of the cells it is impossible to decide whether the objects seen are bivalents or univalents. We suggest that the number 11 may have originated through fragmentation rather than through non-disjunction. Animal mycoplasmas are known to be able to induce chromosome fragmentation in cultured human cells (FOGH and FOGH 1973).

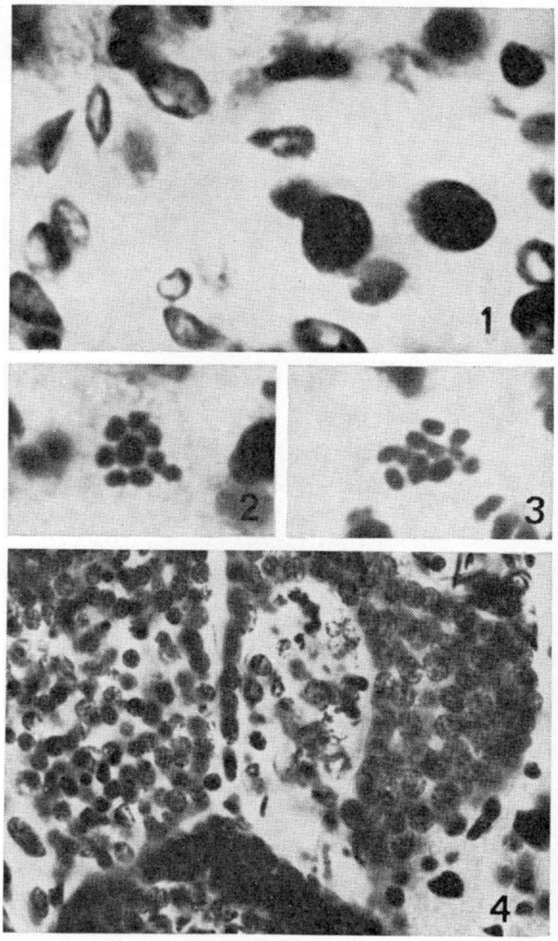

Fig. 1. Deformed and vacuolized sperm heads of variable sizes in a testis cys of *Macrosteles laevis*. × 2400.

Fig. 2. Normal I metaphase cell from a control group specimen. There are 8 bivalents and a univalent X chromosome which is peripherally situated. × 2400.

Fig. 3. I M cell with 11 chromosomes, from an AYA group specimen. × 2400.

Fig. 4. Abnormal piece of tissue intruding into normal-looking part of the testis. × 460.

In our experiment, leafhoppers reared on AYA-infected plants showed definitely more disturbance at spermatogenesis than control group leafhoppers. In the topography of many of the local lesions, the general appearance of the affected part of the testis indicated the presence of an agent capable of self-multiplication. Necrotic pockets intruding into healthy-looking tissues, as seen in some of the follicles (Fig. 4) cannot easily be attributed to any physical or chemical agent. Microbes, on the other hand, may form infection foci with a locally high titre of the microbe. It thus seems highly probable that the severe lesions in the testes of the leafhoppers exposed to AYA are due to the action of this microbe. We suggest that relatively minor disturbances, including changes in chromosome number in some of the cell lines, are also caused by the microbe.

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M. Raatikainen
University of Jyväskylä
Department of Biology
Vapaudenkatu 4
SF-40100 Jyväskylä 10, Finland

O. Halkka
L. Halkka
R. Hovinen
Department of Genetics
University of Helsinki
P. Rautatiekatu 13
SF-00100 Helsinki 10, Finland

A. Vasarainen
Agricultural Research Centre
Department of Pest Investigation
SF-01300 Vantaa 30, Finland

SELOSTUS

Häiriöitä siittiösolujen muodostumisessa aster yellows-mikrobin infektoimissa Macrosteles laevis (Rib.)-kaskaissa

Mikko Raatikainen
Jyväskylän Yliopisto

Olli Halkka
Liisa Halkka
Riitta Hovinen
Helsingin Yliopisto

Arja Vasarainen
Maatalouden tutkimuskeskus

Aster yellows-mikrobin saastuttamilla kasveilla eläneiden koiraskaskaiden kykyä muodostaa normaaleja siittiöitä verrattiin terveillä kasveilla eläneiden kaskaiden vastaavaan kykyyn. Sairaista kasveista mikrobi säännön mukaan siirtyi myös kaskaisiin. Kasveista ilmeisen mikrobitartunnan saaneiden kaskaiden sukusolunmuodostuksessa todettiin monenlaisia häiriöitä. Eräissä yksilöissä todettiin mm. kromosomien katkeamisia ja tumien tuhoutumista. Siittiöt olivat varsin yleisesti kooltaan ja muodoltaan epänormaaleja. Häiriöilmiöiden lokeroittainen esiintyminen siittiörauhasessa viittaa mikrobin läsnäoloon ja lisääntymiseen rauhasen soluissa. Häiriöt johtunevat mikrobin läsnäolosta, mutta voivat myös olla osittain tai kokonaankin seurausta muualla sijaitsevan mikrobin aiheuttamista aineenvaihduntahäiriöistä.

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CONTROL OF RHOPALOSIPHUM PADI (L.) (HOM., APHIDIDAE) ON CEREALS

JORMA RAUTAPÄÄ and JUHANI UOTI

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In field experiments the largest yield losses caused by R. *padi* were 999 kg/ha (29.6 %) on barley, 967 kg/ha (23.7 %) on oats, and 345 kg/ha (7.2 %) on wheat. The respective maximum numbers of aphids on main shoots in untreated plots were 121, 157, and 27. The yield losses correlated significantly with the maximum numbers of aphids on main shoots and with the "aphid index", i.e. the sum of aphids living on main shoots each day during the experiment. When the maximum number of aphids per main shoot increased by 10, the yield loss of all cereals increased by 137 kg/ha (2.9 %), and when the aphid index increased by 100, the yield loss increased by 144 kg/ha (1.1 %).

One or two sprayings at an early stage of aphid population growth reduced their numbers adequatly. The costs of insecticides and labour for two dimethoate or parathion sprayings applied by tractor sprayer corresponded to a yield increase of 250 kg/ha, and this was achieved by successful control when maximum numbers of aphids per main shoot in untreated cereals exceeded 25, or when the aphid index exceeded 300.

Index words: cereal aphids, chemical control.

In recent years yield losses caused by the cereal aphids *Rhopalosiphum padi* (L.). *Sitobion avenae* (F.) and *Acyrthosiphon dirhodum* (Wlk.) have been shown in many field studies (see e.g. KOLBE 1969, 1973, WETZEL 1972, CARRILLO et al. 1974), in the laboratory (LOWE 1974) as well as in cages (RAUTAPÄÄ 1966, 1968 a and b, 1972, 1975). In several countries the importance of cereal aphids has increased even though aphid are known to have infested cereals in large numbers since the beginning of century (see KOLBE 1969, VAPPULA 1965). At present it is not known whether aphids really have become more common and abundant or whether it is merely a question of increased interest in them. It was believed earlier that aphids hardly affected cereal yield.

The first trials with chemical control in this country were made in 1959, when R. *padi* was extremely abundant (RAATIKAINEN and TINNILÄ 1961). In these trials, however, the prime motive was to study the effect of insecticides on aphids. Yield losses were estimated by agricultural advisors, and in oats were about 12 %, in barley 8 % and in wheat 3 % on average for the whole country. This report presents the results of field experiments in which the chemical control of aphids was clarified.

Table 1. Control of R. *padi* in preliminary experiments. Application rate in all experiments was 0.4 l/ha active ingredient. Number of aphids per main shoot at the spraying time were as follows: a 28, b 50—100, c—e 30—50, f and g 50.

Treatment	Date of spraying	Number of plots	Size of plots, m^2	Yield kg/ha	Yield loss %
a barley 'Otra'					
untreated				3471	11.2
bromophos	2 July 68	3	900	3909	
b barley 'Pomo'					
untreated				4374	3.1
dimethoate	8 July 70		1170	4515	
c barley 'Otra'					
untreated				4761	—
dimethoate	10 July 70	2	213	4612	7.8
d barley 'Otra'					
untreated				4897	2.1
dimethoate	10 July 70	2	213	5002	
e barley 'Pomo'					
untreated				3392	0
dimethoate	10 July 70	3	270	3384	
f barley 'Pomo					
untreated				4158	6.2
dimethoate	23 June 70	3	80	4388	
g barley 'Birgitta'					
untreated				5185	3.0
dimethoate	13 July 71	4	450	5345	

Table 2. Control of R. *padi*, experiment 1. The aphid index represents the sum of aphids living on one shoot on each day of the experiment. The loss of yield was calculated by comparing the yield of each treatment of every variety with the treatment with the highest yield (underlined). Stage of cereal development at the time of spraying is indicated in Fig. 1. Sown 19 May 1971. Size of plots 100 m^2 (4 × 25 m), four replicas. Fertilized 13—23—20—800 kg/ha. Herbicide treatment by Mepro Special (mecoprop + MCPA + dicamba) on June 9 over the whole area. Dimethoate sprayings on June 26 (b), June 26 and July 5 (c), and July 5 (d). Chlormequat chloride sprayed over the whole area on June 9 with 3 l/ha. Yield was harvested on August 18.

Treatment		Yield kg/ha	Otra barley Aphid index	Aphid maxim.
a Untreated		6067	1036	68
loss of	%	3.5		
yield	kg/ha	220		
b Dimethoate		<u>6287</u>	193	10
	%	0		
	kg/ha	0		
c Dimethoate		6262	51	2
	%	0.4		
	kg/ha	25		
d Dimethoate		6276	153	17
	%	0.2		
	kg/ha	25		

The experiments were performed in 1968, 1970, 1971, 1973 and 1975 at Kotkaniemi experimental farm belonging to the Kemira Company, in Vihti, South Finland (N). Details of farming techniques, soil fertilization, size of plots, use of herbicides etc. are given in Tables 1 and 2. The experiments were located in fields which were known to be naturally infected by aphids. The abundance of barley yellow dwarf virus in the plants was not determined.

Insecticides

The preparations used are listed in Tables 1—4. The insecticides were sprayed using the Azo-Propan knap-sack sprayer. The pressure used was 3 MPa, and quantity of water 200 litres per hectare.

Aphid populations

In 1968, 1970 and 1971 preliminary experiments were carried out in which only average numbers of aphids on main shoots at the time of spraying were counted. In other experiments, in 1971, 1973 and 1975, the number of aphids was counted several times during the experiment (see Fig. 1). At the time of inspection 10 plants were taken from each plot and the aphids were counted from the main shoot.

Analyses of results

A special "aphid index" was calculated on the basis of the mean number of aphids on main shoot and the time during which the

Table 3. Control of *R. padi*, experiment 2. For explanation of aphid index and method of calculating yield loss see Table 2 and the text. Oat was sown on 14 May, barley on May 24 1973. Size of plots 50 m², 4 replicas. Herbicide spraying of oat on June 6 by Mepro Special (see Table 2) and of barley on June 13 by 4 Actril (dichlorprop + MCPA + ioxynil + bromoxynil). Chlormequat chloride sprayings of oat on 6 June and barley on June 13. Barley was irrigated on June 20 by 30 mm of rain. Insecticide sprayings of oat on June 19 and June 21, and of barley on June 26. Barley was sprayed with 1 l/ha and oat with 2.5 l/ha in treatments b and c, and with 2 l/ha in treatments d and e.

Treatment		Pomo-barley Yield kg/ha	Pomo-barley Aphid index	Pomo-barley Aphid maxim.	Ryhti-oat Yield kg/ha	Ryhti-oat Aphid index	Ryhti-oat Aphid maxim.
a Untreated		2377	1047	121	3108	1901	157
loss of	%	29.6			23.7		
yield	kg/ha	999			967		
b Dimethoate		3323	78	12	4058	349	29
	%	2			0		
	kg/ha	53			17		
c Parathion		3376	25	2	3892	350	41
	%	0			0.4		
	kg/ha	0			183		
d Methidathion		3282	30	3	3367	800	101
	%	2.8			17.4		
	kg/ha	94			708		
e Triazophos		2791	500	73	4075	140	19
	%	17.0			0		
	kg/ha	585			0		

Table 4. Control of R. *padi*, experiment 3. For explanation of aphid index and method of calculating yield loss, see Table 2 and the text. Sown May 10 1975. Size of plots 25 m² (2.5 × 10 m), two replicas. Fertilized with 15—20—15—700 kg/ha. Herbicide spraying with Actril 4 (see Table 2) on June 9, 3 l/ha, over the whole area. Dimethoate sprayings on June 9 (b), June 16 (c), June 23 (d) and June 30 (e). Chlormequat chloride sprayed on June 10 over the whole area. Barley yield was harvested on August 12, that of oat on August 18 and that of wheat on August 28.

Treatments		Paavo-barley			Pomo-barley			Risto-oat		
		Yield kg/ha	Aphid index	Aphid maxim.	Yield kg/ha	Aphid index	Aphid maxim.	Yield kg/ha	Aphid index	Aphid maxim.
a Untreated		5491	812	76	5355	810	60	4303	701	44
loss of	%	12.0			11.5			6.2		
yield	kg/ha	746			699			283		
b Dimethoate		5946	400	28	<u>6054</u>	394	24	<u>4586</u>	225	15
	%	4.7			0			0		
	kg/ha	291			0			0		
c Dimethoate		<u>6237</u>	141	16	5818	149	16	4348	197	26
	%	0			3.9			5.2		
	kg/ha	0			236			248		
d Dimethoate		6158	333	54	5856	334	45	4325	444	41
	%	1.3			3.3			5.7		
	kg/ha	79			198			261		
e Dimethoate		5831	654	76	5689	599	60	4179	607	44
	%	6.5			6.0			8.9		
	kg/ha	406			365			407		

Treatments		Ryhti-oat			Ruso-wheat			Tähti-wheat		
		Yield kg/ha	Aphid index	Aphid maxim.	Yield kg/ha	Aphid index	Aphid maxim.	Yield kg/ha	Aphid index	Aphid maxim.
a Untreated		4143	600	37	4764	384	22	4361	434	27
loss of	%	4.0			1.0			5.8		
yield	kg/ha	189			42			269		
b Dimethoate		4146	259	18	<u>4806</u>	224	12	<u>4630</u>	154	11
	%	4.3			0			0		
	kg/ha	186			0			0		
c Dimethoate		4317	180	18	4461	103	9	4585	142	13
	%	0.3			7.2			1.0		
	kg/ha	15			345			45		
d Dimethoate		<u>4332</u>	317	25	4776	156	19	4381	245	24
	%	0			0.6			5.4		
	kg/ha	0			30			249		
e Dimethoate		4173	503	37	4807	283	22	4389	376	27
	%	3.4			0			5.2		
	kg/ha	159			0			241		

aphids were living on plants. This index represents the total number of aphids living on main shoot on each day of the experiment. The same index has been used previously to describe the population level of cereal aphids (e.g. Rautapää 1975).

The variation in yield was calculated by comparing the grain yield with each treatment of every variety to the treatment with the highest yield. In Tables 2—4 the highest yield for every variety used as a comparison is underlined. The variation with certain

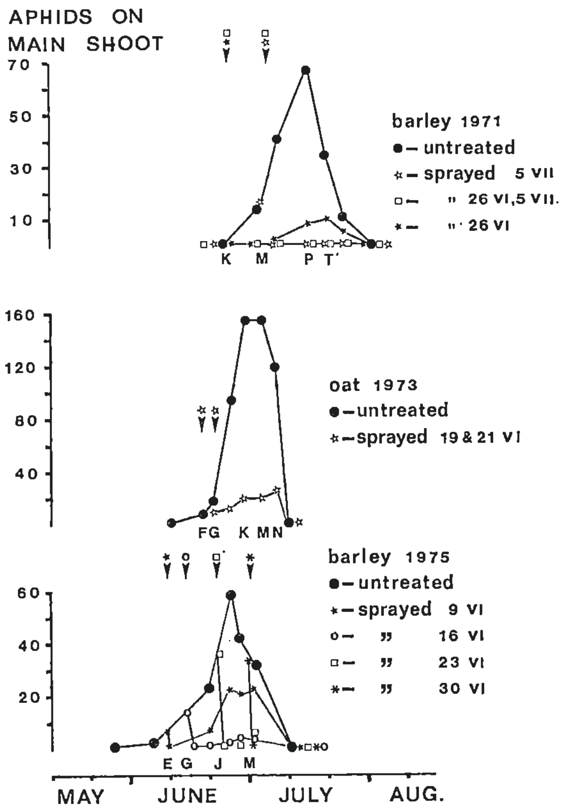

Fig. 1. Examples of the effect of insecticides on R. *padi* populations in 1971, 1973 and 1975. Time of spraying is indicated by arrows, and stage of development of plants by Keller and Baggiolini — scale letters.

treatments thus obtained was not correlated with the aphid maximum or aphid index for this treatment, but with the difference between aphid maximum or aphid index for this treatment and the treatment with the highest yield. This difference in aphid maximum or aphid index was supposed to describe the aphid population which caused the yield loss of a certain treatment as compared with the highest yield.

RESULTS

Aphid populations

In all the experiments the most abundant species was R. *padi*.

Only a few specimens of *A. dirhodum* were observed and the largest numbers even of *S. avenae* were 1—2 aphids per main shoot. The maximum numbers and indices of *A. dirhodum* and *S. avenae* were less than 1 % of those for R. *padi*. However, all the figures representing the aphid abundance cited later on indicate the total sum of aphids, though R. *padi* was the dominant species.

In preliminary experiments (Table 1) the number of aphids at the time of spraying varied from 28 to over 50 per main shoot. No further observations on aphids were made in these tests.

In the 1971 the first aphids were observed in cereals on June 20, in 1973 about June 15, and in 1975 during the last week of May (Fig. 1).

The greatest numbers of aphids per shoot in the years 1971, 1973 and 1975 are presented in Fig. 1. In 1971 the maximum number of aphids (68/main shoot) in untreated barley occured in the middle of July. In 1973 the maximum (152/main shoot) occured about the end of June and beginning of July. In 1975 the maximum (59/main shoot) was during the last week of June. In barley and oats the greatest numbers were about the same but on wheat (in 1975) somewhat smaller (22 and 27, Table 4). The aphid populations declined soon after reaching its peak and disappeared before harvesting time. The largest aphid indices were calculated in 1973 for untreated 'Ryhti'-oats (1901) and untreated 'Pomo'-Barley (1047, Table 3). In other experiments the indices for untreated plots were smaller but nevertheless amounted to several hundred. Even on wheat the indices were about 400 in 1975 (Table 4).

Effect of insecticides on aphids

There were no significant differences between the insecticides used: all of them reduced the aphid populations (Tables 2—4, Fig. 1). However, some differences may be distinguished between the cereals. In 1973 aphids living on barley disappeared almost totally after spraying with dimethoate or parathion, but those living on oats did not. In 1975, dimethoate and parathion were effective against aphids on barley and oats but not against aphids living on wheat. In 1971 and '75 one spraying, when the aphid population was starting to grow, reduced the population increase for about one week. After that the number of aphids began to build up, but with these treatments the maximum numbers did not reach the same levels as in untreated plots (see Fig. 1 and Tables 2—4).

In 1971 two dimethoate sprayings at ten day intervals almost totally eliminated aphid populations for the whole period of barley growth (Fig. 1). The aphid maximum on treated plants was 2 and the index only 51, indicating that the plants were practically free from aphids. In 1973 two sprayings of dimethoate and parathion almost totally controlled aphids on barley but not on oats. The aphid maximums and indices on treated barley were 4 and 78, but those on oats 29 and 349, or about 20 % of the corresponding index calculated for untreated plots. The other insecticides used in 1973, triazophos and methidathion, gave varying results (Table 3). Spraying the plots later, when the number of aphids reached some dozens per main shoot, resulted in a quick, almost total disappearance of aphids. However, the maximum numbers and the indices of these late sprayed treatments were relatively high because of the number of aphids living on plants before spraying.

Effect of aphids on yield

In preliminary experiments in 1968, 1970 and 1971 (Table 1), the yield decrease varied from 0 to 438 kg/ha (0—11.2 %). At the time of spraying the number of aphids per shoot was relatively high, in most cases over 50.

The largest yield loss on barley was 999 kg/ha (29.6 %) and on oats 967 kg/ha (23.7 %), both in 1973 (Table 3). On wheat the corresponding figure was 345 kg/ha (7.2 %) in 1975 (Table 4). Yield losses above 700 kg/ha were also recorded for barley in 1975. In other experiments yield losses were smaller.

Yield losses correlated significantly with the maximum number of aphids per main shoot in each treatment ($r = +0.885$, $P<0.01$, $y = 64.1 + 7.3\,x$) and with the aphid indices ($r = +0.834$, $P<0.01$, $y = 75.8 + 0.68\,x$) (Figs. 2 and 3). The difference between the regressions based on maximum numbers of aphids and

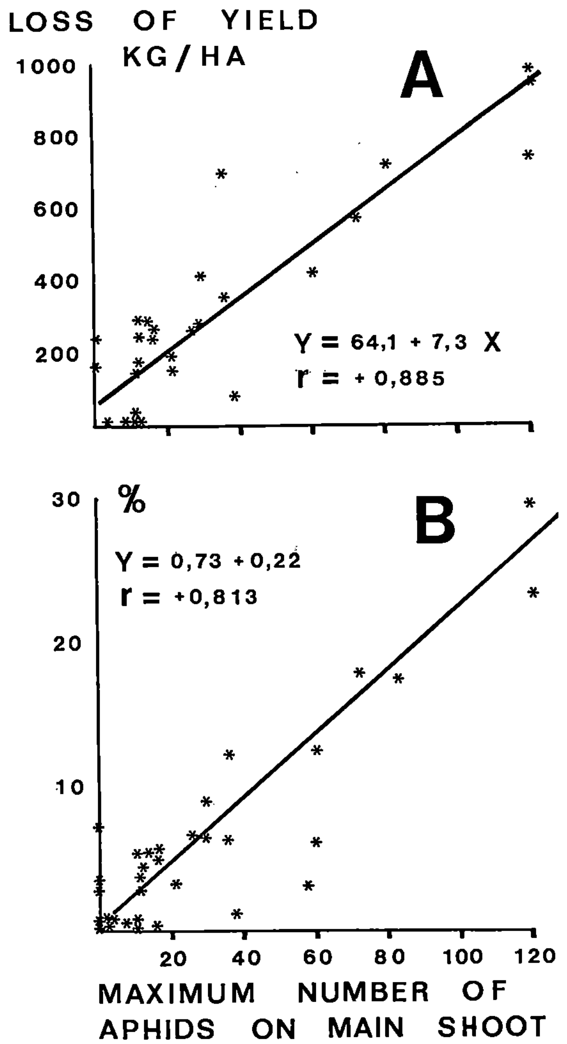

Fig. 2. Correlation between the maximum number of aphids per main shoot and (A) yield loss in kg/ha, (B) yield loss in percentages. Both the correlations were highly significant (P <0.01).

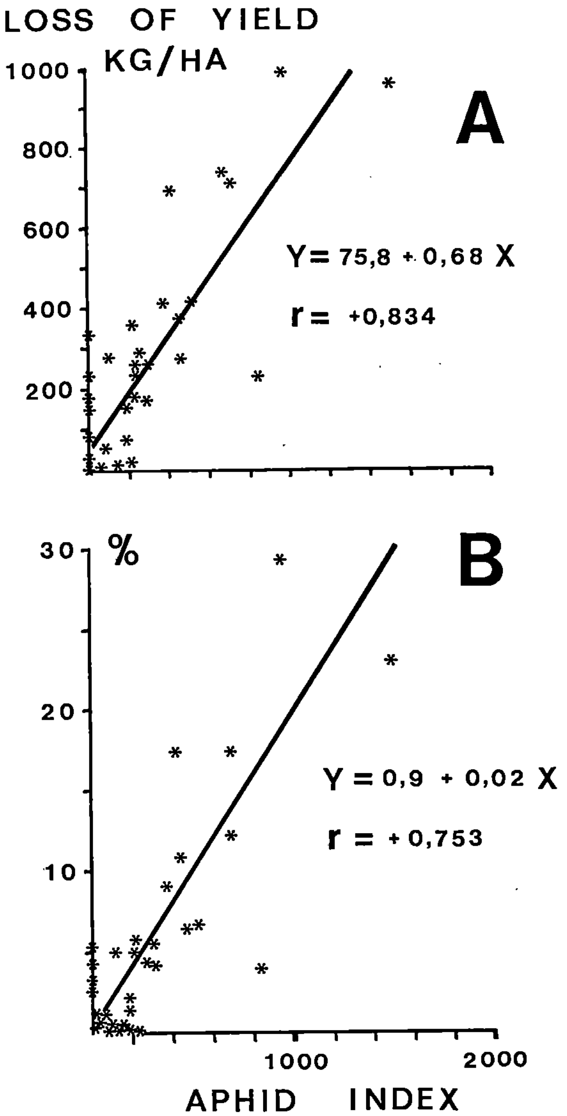

Fig. 3. Correlation between the aphid index (for explanation, see text) and (A) yield loss in kg/ha, (B) yield loss in percentages. Both the correlations were highly significant (P <0.01).

the aphids indices was not significant. When the maximum number of aphids increased by 10, yield decreased by 137 kg/ha (2.9 percentage units). On the other hand, when the aphid indes increased by 100 units, yield decreased by 756 kg/ha (1.1 percentage units) (Figs. 2 and 3). The yield losses in barley, oats and wheat corresponding to a certain aphid maximum or aphid index proved to be about the same.

DISCUSSION

The population growth of R. *padi* in untreated plots was rapid and the whole period of existence lasted about four five weeks. The most critical period from the start of the population growth until its maximum did not last more than two to three weeks. Therefore, the effect of insecticides on aphids, if applied at the right time, need not necessarily last longer than two weeks. In some tests even one spraying at the beginning of aphid population growth reduced aphid numbers effectively for about one week. After this period the number of aphids began to increase, but it did not reach the same levels as on untreated cereals. Two successive sprayings reduced aphid populations effectively for the whole period of cereal growth.

In most cases the largest yield was obtained from plots sprayed at the very beginning of aphid increase. However, aphid populations, counted according to the maximum number of aphids per shoot and by aphid indices, were not always smallest among these treatments giving the highest yield. This may indicate that the earlier stages of cereal growth are more sensitive to aphids than the later ones. This difference between the cereal growth stages has been pointed out by some authors (WELLS and MACDONALD 1961, APABLAZA and ROBINSON 1967, ANON. 1972, WETZEL 1972, KOLBE 1973). However, in cage experiments made by RAUTAPÄÄ (1966, 1968 a and b, 1972) the difference between earlier growth stages, from appearence of last sheath until beginning of flowering, could not be proved though infestation beginning during the late stage of flowering in barley did not affect the yield (RAUTAPÄÄ 1975). In any case, yield losses seem to correlate significantly with aphid populations, which can be measured either by the greatest number of aphids per shoot or by the total sum of aphids living each day of the experiment on the main shoot, i.e. the so called "aphid index". In cage experiments the yield changes correlated significantly better with the index than with the maximum number of aphids on shoots but this was not the case in field tests.

The cost of two sprayings, using 2 litres of dimethoate or parathion was about 50 Fmk per hectare (about 12 US $) according to the prices of insecticides in 1975. The costs for two tractor sprayings were estimated to be about 100 Fmk/ha and the total costs of two tractor sprayings about 150 Fmk. The prices paid to farmers in December 1975 for one ton grain yield were about 630 Fmk for oats, 670 Fmk for barley and 840 Fmk for wheat. On average, the costs of two sprayings correspond to the income from 250 kg grain yield. According to the results of these experiments R. *padi* population with a maximum number of aphids per main shoot about 25 or with an aphid index of more than 300 decreased yield by 250 kg per hectare.

About the same conclusion has been drawn by other authors. KOLBE (1973) reviewed a large number of field experiments and presented about 20 aphids per head or shoot as the critical level for damage. At least 20 aphids per plant has been used in Sweden as a threshold value motivating in practice the use of insecticides (NILSSON 1973), and STERN and BOWEN (1967) mentioned that "when aphid populations are expected to reach 25 to 30 aphids per tiller, barley yields may be reduced if the aphids are not controlled".

The problem is how to predict the population level of aphids early enough to decide whether control measures are nesessary or not. Spraying has to be carried out during a relatively short period at the beginning of population growth. In preliminary experiments (see Table 1) almost all spraying was done too late and therefore the yield increases remained small even if number of aphids on plants was high at the time of spraying.

Practical advice to help farmers decide whether control measures are necessary has been given (i.e. NILSSON 1973) and several methods for estimating the yield loss to be expected due to cereal aphids (KOLBE 1973, KOLBE and LINKE 1974, BARAN and PIDANY 1973, 1975, RAUTAPÄÄ 1966—1975) have been published, but these cannot be considered prognosis methods applicable for predicting population growth. Efforts to correlate aphid populations with the weather have not succeeded (DEAN 1974) even though some proof of the importance of temperatures during spring and the beginning of summer has been obtained (JONES 1972). Even the numbers of migrating aphids do not seem to correlate with population levels on cereals (DEAN 1974).

However, a simple method, developed on the basis of long-term population studies, has been published in Finnish for the use of farmers (RAUTAPÄÄ 1974 a and b). By this method it seems possible to predict the population level of aphids simply by counting at an early stage of infestation.

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Jorma Rautapää
Agricultural Research Centre
Institute of Pest Investigation
SF-01300 Vantaa 30, Finland

Juhani Uoti
Kemira Oy
Malminkatu 30
00100 Helsinki 10, Finland

SELOSTUS

Tuomikirvan torjunta viljoissa

JORMA RAUTAPÄÄ — Maatalouden tutkimuskeskus

JUHANI UOTI — Kemira Oy

Tuomikirvan torjuntaa kevätviljoissa selvitettiin vuosina 1968—1975 Kemira Oy:n Kotkaniemen koetilalla Vihdissä. Vuosina 1968—1971 tehtiin alustavat kokeet, joissa laskettiin kirvojen määrät vain ruiskutushetkellä; 1971—1975 seurattiin tarkemmin torjunnan vaikutusta tuomikirvaan.

Yleensä oli kirvoja käsittelemättömässä ohrassa ja kaurassa yhtä paljon mutta kevätvehnässä vähemmän. Suurimmat kirvamäärät käsittelemättömissä viljoissa olivat: 1971 'Otra'-ohrassa keskimäärin 68, 1973 'Ryhti'-kaurassa 152 ja 1975 'Pomo'-ohrassa 59 kirvaa pääversossa.

Yksi dimetoaatti- tai parationiruiskutus (1 l. kauppavalm./ha) versomisen alkaessa ja kirvojen määrän ollessa pieni hävitti tuomikirvat lähes täysin, mutta kirvat alkoivat lisääntyä runsaan viikon kuluttua saavuttamatta kuitenkaan yhtä suurta määrää kuin käsittelemättömissä viljoissa. Kaksi peräkkäistä ruiskutusta 3—10 päivän välein vähensi kirvojen määrän pieneksi, eivätkä ne myöhemmin enää lisääntyneet haitallisesti. Dimetoaatti ja parationi tehosivat kirvoihin hyvin myöhemminkin kasvuston ollessa tähkien ja röyhyjen esiintulon aikaan ruiskutettaessa tiheätä ja korkeaa.

Alustavissa kokeissa 1968—1971 aleni viljojen sato ilman kirvojen torjuntaa 0—438 kg/ha (0—11.2 %). Ruiskutettaessa oli kirvojen määrä pääversossa vähintään 28 ja eräissä tapauksissa yli 50.

Vuosien 1971—1975 kokeissa oli ohran suurin satotappio ilman torjuntaa 999 kg/ha (29.9 %) vuonna 1973, kauran 967 kg/ha (23.7 %) samoin 1973 ja vehnän 345 kg/ha (7.2 %) vuonna 1975. Näissä tapauksissa oli ohrassa enimmillään 121, kaurassa 157 ja vehnässä 27 tuomikirvaa pääversossa.

Sadonalennukset korreloituivat kirvojen määriin eikä satotappion suuruus riippunut viljalajista eikä -lajikkeesta. Kun suurin kirvamäärä pääversossa kasvukauden aikana suureni 10:llä, lisääntyi satotappio 137 kg/ha (2.9 %). Kun kirvaindeksi (= koeajan kunakin päivänä pääversossa keskimäärin eläneiden kirvojen summa) suureni 100:lla, lisääntyi satotappio 144 kg/ha (1.1 %).

Kahden dimetoaatti- tai parationiruiskutuksen ainekustannukset (yht. 2 l. kauppavalm./ha) olivat vuoden 1975 vähittäismyyntihintojen mukaan noin 50:—/ha ja työkustannukset traktoriruiskua käytettäessä noin 100:—/ha. Kahden ruiskutuksen kustannukset olivat yhteensä noin 150:—/ha. Vuoden 1975 joulukuussa maksettujen viljan hintojen mukaan torjunnan aine- ja työkustannukset peittyivät, kun sato suureni keskimäärin 250 kg/ha. Tämän suuruisen sadonalennuksen tuomikirva aiheutti silloin kun sen suurin määrä pääversossa oli kasvukauden aikana keskimäärin vähintään 25 tai kirvaindeksi vähintään 300.

ANNALES AGRICULTURAE FENNIAE, VOL. 15: 111—115 (1976)

Seria ANIMALIA NOCENTIA N. 86 — Sarja TUHOELÄIMET n:o 86

THE DISTRIBUTION OF THE POTATO CYST NEMATODE, HETERODERA ROSTOCHIENSIS WOLLENWEBER, IN FINLAND

MARJA LEENA SARAKOSKI

SARAKOSKI, M. L. 1976. **The distribution of the potato cyst nematode, Heterodera rostochiensis Wollenweber, in Finland.** Ann. Agric. Fenn. 15: 111—115. (Agric. Res. Centre, Inst. of Pest Inv., SF-01300 Vantaa 30, Finland).

The potato cyst nematode, *Heterodera rostochiensis* Wollenweber, was discovered in Finland for the first time in 1946. New discoveries were made infrequently at first and infestations were concentrated mainly to southern parts of the country. It was not until the end of the 1960s that the number of new discoveries began to increase rapidly. So that control methods could be planned and spreading detained, more details were required on the distribution of the potato cyst nematode. A distribution survey was therefore started in 1974. No infestations had been recorded in Ostrobothnia before that time. The survey revealed however, that eight farms in Ostrobothnia were infested by the nematode. Quite apart from the survey, the nematode has been found in many fields both in Ostrobothnia and elsewhere in Finland.

Index words: *H. pallida,* Nematoda, white potato cyst nematode, survey, infestation.

Introduction

The potato cyst nematode, *Heterodera rostochiensis* Wollenweber, is a serious problem in nearly all areas where potatoes are grown. It is no newcomer to the poato fields of Europe and was first observed in the 19th century. In 1881 J. Kühn found a cyst-forming nematode that lived in the roots of the potato in Germany. This cyst nematode was also found later in Scotland, England, Sweden and Ireland (FRANKLIN 1951). In 1923, Wollenweber described it as an independent species, for which he suggested the name *Heterodera rostochiensis* after the place (Rostock) where it had been first discovered (WOLLENWEBER 1923).

The potato cyst nematode originated in South America, as did the potato itself (FRANKLIN 1951). It was probably introduced into North America and Europe together with the potato in the 19th century, but it was not until the advent of modern agriculture that it became a notable potato pest.

The potato cyst nematode was found for the first time in Finland in Hyvinkää south Finland in 1946 (VAPPULA 1954). New discoveries were infrequent in the beginning and infestations were limited to small plots that were of little significance to the country's potato production. During the 1970s the potato cyst nematode was discovered in larger fields specializing in commercial potato cultivation.

For planning control methods and to provide a basis for implementing them, more facts about the distribution of the species were needed and a distribution survey was therefore started in western Finland in 1974.

Material and methods

Earlier records of discoveries of the potato cyst nematode were based on sporadic reports sent to the Agricultural Research Centre by farmers and regional agricultural advisers, and on individual observations made by scientists from the Department of Pest Investigation. However, no organized distribution survey was undertaken until the summer of 1974 when some communes in the Province of Häme were examined.

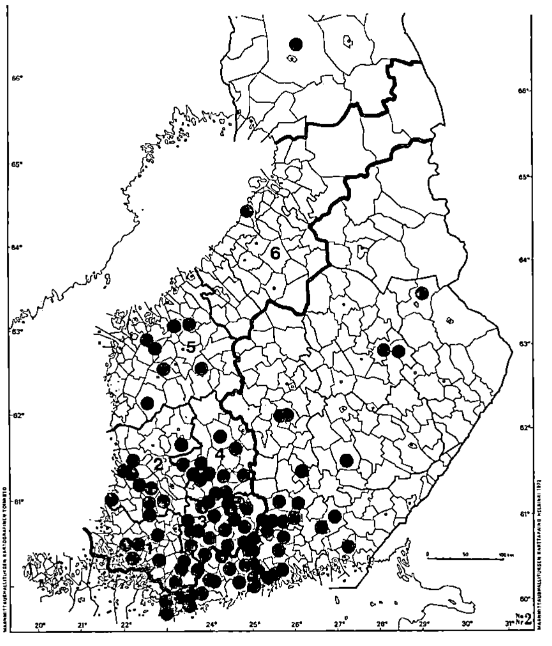

Fig. 1. The distribution of the potato cyst nematode in Finland. Agricultural Extension Centres where the distribution survey has been carried out: 1. Varsinais-Suomi, 2. Satakunta, 3. Häme, 4. Pirkanmaa, 5. Ostrobothnia, 6. Oulu.

● *Community with infested field (s).*

Later, during autumn 1974, a more extensive distribution survey could be undertaken in western Finland with funds granted by the Ministry of Agriculture and Forestry. The areas selected for the survey were districts of the Agricultural Extension Centres in Varsinais-Suomi, Satakunta, Häme, Pirkanmaa, Ostrobothnia and Oulu (Fig. 1). 195 communes were studied in all. In each commune soil samples were taken from 25 potato-farms. The survey concentrated mostly on potato farms where potatoes had been grown for many years in succession. The agricultural advisers in each extension district collected the soil samples, which were then forwarded to the Viljavuuspalvelu Oy, Turku, laboratory for further examination.

The methods used in soil sampling and in examination were those recommended by EPPO (European and Mediterranean Plant Protection Organization) (Anon. 1973). Each sampling area was 1 ha (0.01 km^2) in size. The volume of the samples was to be at least 250 g. One sample consisted of 50 subsamples taken from the sampling area at regular intervals after the top soil (layer of approx. 5 cm) had been removed. For examination, 200 g air-dried soil were weighed out and the cysts were then separated by Fenwick's extraction method (Fenwick 1940, Oostenbrink 1950).

Results

During the survey the potato cyst nematode was discovered in 37 communes. Of the infested communes, 13 were located in the Province of Häme. In Satakunta and Pirkanmaa the potato cyst nematode was found in six, and in Ostrobothnia seven communes. In Varsinais-Suomi, there were four infested communes and in the Province of Oulu one infested commune. Of all the communes

Table 1. Number of infested communes discovered in the survey.

Province	Examined commun-es	Infested communes discovered in the survey	other observa-tions
Varsinais-Suomi	35	4	6
Satakunta	26	6	4
Häme	22	13	11
Pirkanmaa	23	6	9
Ostrobothnia	36	7	0
Oulu	53	1	0
Total	195	37	30

Table 2. Number of infested fields discovered in the survey.

Province	Examined fields	Infested fields discovered in the surveyr	other observa-tions
Varsinais-Suomi	749	4	6
Satakunta	360	10	4
Häme	544	26	54
Pirkanmaa	512	10	43
Ostrobothnia	730	7	0
Oulu	1283	1	0
Total	4178	58	107

examined percentage infestation was 19 % (Table 1 and Fig. 1).

Samples were taken from a total of 4178 fields. 58 fields were infested and most of these (26 fields) were located in Häme. In both Satakunta and Pirkanmaa, the potato cyst nematode was found in 10 fields, in Ostrobothnia in 7, in Varsinais-Suomi in 4 and in the Province of Oulu in 1 field (Table 2). According to the survey it appeared most frequently in the municipality of Riihimäki (7 fields) and in district of Loppi (6 fields). The corresponding figure for Hämeenkyrö and Pori was 3. In all other communes examined the potato cyst nematode was found in one or two potato-fields.

Most of the potato cyst nematode infestations discovered in the survey were not heavy (Table 4). Only in a few cases was the number of cysts per sample so high that it could cause a considerable decrease in yield. All samples from northern Finland showed slight infestation only. Accordingly, we may assume that the potato cyst nematode has only recently spread to these regions. At present, however, no detailed conclusions can be drawn, because the expansion and living conditions of the potato cyst nematode have not yet been studied in northern Finland.

Quite apart from the distribution survey, numerous soil and plant samples were sent to Viljavuuspalvelu Oy and to the Agricultural Research Centre during summer 1975. Samples from 98 farms were examined at the Agricultural Research Centre. Of these, 58 were found to be infested by the potato cyst nematode. Most samples came either from farmers or from regional agricultural advisers. Most of the discoveries were in areas where the nematode is known to exist in large numbers. A few were made, however, in areas where the nematode had not been found before but where no distribution survey had been made either. Of these we can mention the region of Mikkeli in Lake-Finland, the vicinity of Hamina in south-eastern Finland and the community of Rovaniemi in Lapland, somewhat north of the Arctic Circle. In Ostrobothnia, as well, there have been some discoveries of potato cyst nematodes apart from those made in the survey.

All potato cyst nematodes so far identified in Finland belong to the species *Heterodera rostochiensis* Wollenweber, the yellow potato cyst nematode. The white potato cyst nematode, *H. pallida* Stone has not yet been reported from any part of the country.

Discussion

During the ten years following the first discovery of the potato cyst nematode in 1946, it was found in 75 plots in 4 localities of southern Finland. Towards the end of the 1960s the number of observations began to increase rapidly. The distribution of this nematode expanded to include most of southern Finland, south of latitude 62. About 400 ifested

Table 3. Infestations discovered during the years 1946—1975.

Year	Number of areas where discoveries were made: potato-fields	communes
1946	1	1
1950	52	1
1955	75	4
1960	109	6
1965	213	16
1970	394	50
1974	487	65
1975*)	574	94

*) Incl. survey results from western Finland

fields in over 50 communities were recorded in 1970. At the end of the summer 1974 the number of fields was 469. Infested potato-fields were situated in 65 communes (Table 3 and Fig. 1).

In the distribution survey started in the autumn of 1974, western Finland north as far as Oulu and western parts of the Province of Häme were studied. The central, eastern and northern parts of the country have not been studied yet.

Before the distribution survey, no reports on infestation in Ostrobothnia had reached the Agricultural Research Centre although this area is one of the main regions of potato cultivation. In the survey no less than 8 fields infested by the potato cyst nematode were found in Ostrobothnia. The northernmost observation was from Pattijoki latitude 65.

Some independent discoveries of infestation in northern Finland have been reported as well. Today the northernmost discovery comes from the village of Apukka in Lapland, located a few kilometres north of the Arctic Circle.

Based on the distribution survey as well as on the samples sent to the Agricultural Research Centre, it is obvious that the potato cyst nematode is a serious threat to Finnish potato growing. Although the survey has not yet covered the whole country, it is most probable that the potato cyst nematode has spread to all areas where potato is grown. The latest discoveries show that the nematode apparently thrives wherever the potato does, to the very borders of potato plant's range.

It should also be noted that the number of infested specialized potatofarms and greenhouses where tomatoes are cultivated is steadily increasing. The knowledge we have today does not provide us with a complete picture of the distribution of the potato cyst nematode or of its occurrence in large cultivations. It is therefore necessary to complete the distribution survey and to carry out a detailed survey in the potato-growing areas of major importance. Only then will it be possible to estimate the economic significance of this nematode species. More efficient control methods could then be developed at least in those areas where the potato cyst nematode exists in small numbers.

Table 4. The degrees of infestation discovered in the distribution survey.

Degree of Infestation: Number of cysts/ 200 g soil	The number of fields infested arranged in order of infestation: Varsinais-Suomi	Satakunta	Häme	Pirkanmaa	Ostrobothnia	Oulu	Total
1— 5	4	6	12	1	5	1	28
6— 10	—	2	4	1	1	—	8
11— 20	—	—	2	2	—	—	4
21— 30	—	1	—	—	—	—	1
31— 40	—	—	1	1	1	—	3
41— 50	—	—	2	1	—	—	3
51— 60	—	—	1	—	—	—	1
61— 70	—	1	1	1	—	—	3
71— 80	—	—	—	1	—	—	1
81— 90	—	—	—	—	—	—	0
91—100	—	—	1	—	—	—	1
101—200	—	1	2	—	—	—	3
over 200	—	1	—	—	—	—	1

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MS received 19 January 1976
Marja Leena Sarakoski
Agricultural Research Centre
Institute of Pest Investigation
SF-01300 Vantaa 30, Finland

SELOSTUS

Peruna-ankeroisen levinneisyys Suomessa

MARJA LEENA SARAKOSKI

Maatalouden tutkimuskeskus

Ensimmäinen peruna-ankeroishavainto tehtiin vuonna 1946 Hyvinkäällä. Uusia saastuntoja löydettiin aluksi hitaasti. Vasta 1960-luvun loppupuolella alkoi saastuneiden perunamaiden määrä nopeasti kasvaa, mutta vasta 1970-luvulla tavattiin ankeroista myös laajoilta, perunan viljelyyn erikoistuneilta tiloilta; siihen saakka oli saastuntoja löytynyt vain pieniltä omakotipalstojen perunamailta. Havainnot perustuivat satunnaisiin Maatalouden tutkimuskeskukselle tulleisiin näytteisiin ja ilmoituksiin sekä jossain määrin tuhoeläinosaston tutkijoiden havaintoihin. Syksyllä 1974 aloitettiin järjestelmällinen levinneisyystutkimus Länsi-Suomessa. Tutkimusta on tarkoitus jatkaa seuraavien vuosien aikana muualla Suomessa.

Levinneisyystutkimuksessa tarkastettiin yli 4000 perunamaata. Tutkimusalueena oli Länsi-Suomi Oulun korkeudelle sekä Hämeen läänin länsiosat. Jo ennen tutkimusta oli tiedossa, että peruna-ankeroista esiintyy runsaasti Hämeen perunapelloilla. Myös Satakunnasta ja Varsinais-Suomesta oli ankeroista löydetty, mutta Pohjanmaalta sitä ei oltu tavattu. Tutkimuksessa löydettiin kuitenkin peruna-ankeroista paitsi Hämeestä, Satakunnasta ja Varsinais-Suomesta, myös Pohjanmaalta. Etelä-Pohjanmaalta tavattiin ankeroista kuudelta, Oulun läänistä yhdeltä ja ruotsinkieliseltä Pohjanmaalta yhdeltä tilalta. Kaikki saastunnat olivat lieviä. Myös varsinaisen levinneisyystutkimuksen ulkopuolella on Pohjanmaalta tarkastetuista näytteistä löytynyt ankeroisia, samoin Lapin läänistä napapiirin pohjoispuolelta. Myös nämä saastunnat ovat olleet suhteellisen lieviä. Tämän perusteella on syytä olettaa peruna-ankeroisen vasta äskettäin levinneen Pohjois-Suomeen.

Sekä levinneisyystutkimuksen että Maatalouden tutkimuskeskukselle vuosittain tulevien näytteiden perusteella voidaan päätellä, että peruna-ankeroinen on nopeasti leviämässä perunaviljelmille. Tällä hetkellä on tiedossa 574 ankeroisen saastuttamaa erillistä perunamaata, jotka ovat jakautuneet 94 kunnan alueelle. Saastuntaa on löytynyt yhä enemmän myös perunan viljelyyn erikoistuneilta tiloilta. Mutta ennen kuin voidaan edes karkeasti arvioida ankeroisen vuosittain aiheuttamia tappioita, on levinneisyystutkimus saatettava päätökseen sekä suoritettava tärkeimmillä perunan viljelyalueilla tarkempaa kartoitusta.

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Seria ANIMALIA NOCENTIA N. 87 — Sarja TUHOELÄIMET n:o 87

BUMBLEBEES, BOMBUS LATR. (HYMENOPTERA, APIDAE), ON RED CLOVER IN SOUTH SAVO, FINLAND

ILKKA TERÄS

TERÄS, I. 1976. **Bumblebees, Bombus Latr. (Hymenoptera, Apidae), on red clover in South Savo, Finland.** Ann. Agric. Fenn. 15: 116—127.
(Dept. Zool., Univ. Helsinki, P. Rautatiekatu 13, SF-00100 Helsinki 10, Finland).

The visits of bumblebees to red clover were studied in 1972—1974, and the results compared with the observations made at the same place (61°N, 27°E) in 1960—1966. The numbers of bumblebee individuals varied a great deal during the summers of the investigation, but total numbers were lower than in 1960—1961; in particular, B. *distinguendus* had decreased. Altogether 11 species were seen on red clower fields, the most common being *B. lucorum* (in 1972 and 1974), *B. pascuorum*, *B. hortorum*, and *B. lapidarius* (in 1972 and 1973). The proportion of robber bumblebees, mostly *B. lucorum*, was 56 % in 1972 and 81 % in 1974, but less than 1 % in 1973 when *B. lucorum* preferred *Phacelia tanacetifolia* to red clover. Most robbers were observed during the first half of the flowering season. Bumblebees robbed most frequently during the afternoon while maximum nectar collecting took place in the evening and maximum pollen collecting in the morning. Nectar collectors were more common than pollen collectors. Red clover visitors were usually workers and queens; male bumblebees only occasionally visited red clover. Flowers growing at the sides of the red clover fields were visited more than those in the centre. The best seed yields (over 700 kg/ha) were achieved in 1973 when weather conditions were favourable and the numbers of bumblebee pollinators were high.

Index words: *Bombus*, red clover, flower visits.

Introduction

In Finland, bumblebees, *Bombus* Latr., are the most efficient red clover pollinators. Their importance lies in their being more numerous than other potential pollinators, for example honeybees, and their being the only insects which can properly pollinate the cultivated tetraploid varieties, with long corolla tubes. Bumblebees are especially important in South Savo and other places in Central Finland, where there are fewer bee-keepers than in the southern parts of the country and where red clover flowers have longer corolla tubes.

The flower visits by Finnish bumblebees have been investigated thoroughly by HULK-

KONEN (1928) and ELFVING (1968). Bumblebees as pollinators of red clover were studied as early as the 1930's by POHJAKALLIO (1938) and KORCKMAN (1938). Since then, VALLE (e.g. VALLE 1948, 1955, 1959, 1966, VALLE et al. 1960, 1962, 1964) and HÄNNINEN (1962) have also made extensive studies dealing with tetraploid red clover.

South Savo Agricultural Experiment Station near Mikkeli was one of the places where Professor VALLE studied bumblebees and red clover in 1960—1964 (see VALLE et al. 1960, 1964, VALLE 1966). The same fields were studied by MELA (1969) in 1965—1966. The present study gives information on bumblebee visits to tetraploid red clover at South Savo Agricultural Experiment Station in 1972—1974, with comparisons to the above mentioned earlier studies; some of the unpublished observations made by VALLE in 1964 are also included.

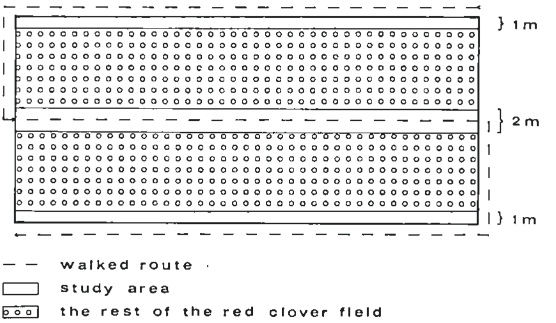

Fig. 1. Pattern of the investigation route walked on the red clover field three or four times a day in 1972—1974.

Material and methods

South Savo Agricultural Experiment Station is situated at Karila near Mikkeli (61°41′ N, 27°15′ E). Bumblebee studies were made on tetraploid red clover fields (variety TEPA):

year	area m²	red clover harvested	seed yield kg/ha
1972	9000	Aug. 25	320
1973	6400	Aug. 16	500—800
1974	900	in Sept.	under 10

The same field was used in 1972 and 1973, while in 1974 the red clover was growing about 500 m SE from the site of the previous years.

Bumblebees were counted two days a week at 09, 13, 17, and 21 hrs in July and at 09, 13, and 17 hrs in August (in 1974 only at 09, 13 and 17 hrs). The counting was carried out if it was drizzling but not during heavy rain. The study area consisted of three lengthwise field strips, one 2 m wide in the centre of the field and two 1 m wide along the sides of the field (Fig. 1). The study area formed in this ways was 750 m² in 1972, 600 m² in 1973, and 100 m² in 1974. Every bumblebee was identified visually according to its colour markings (see ELFVING 1960), and for this reason some *B. lapidarius* and *B. ruderarius* males may have been confused. Feeding habits (pollen collecting, nectar collecting, nectar robbing) were also recorded.

During the three summers of the investigations red clover visits by following bumblebee species were observed (abbreviations used in the figures and tables are presented in parentheses):

B. distinguendus Mor.	(dist)	*B. pascuorum* (Scop)	(pasc)
B. hortorum (L.)	(hort)	*B. pratorum* (L.)	(prat)
B. hypnorum (L.)	(hypn)	*B. ruderarius* (Müll.)	(rud)
B. jonellus (Kby)	(jon)	*B. soroeensis* (F.)	(sor)
B. lapidarius (L.)	(lap)	*B. veteranus* (F.)	(vet)
B. lucorum (L.)	(luc)		

Nomenclature is according to LØKEN (1973). *B. sylvarum* (L.) was also seen in the station area but it did not visit red clover.

The numbers of bumblebees seen to visit red clover are presented in Table 1. The first visits were observed on July 4 in 1972, on July 2 in 1973, and on July 25 in 1974.

Table 1. Numbers of bumblebee species and individuals observed at Karila in 1972—1974.

	1972 (750 m²)				1973 (600 m²)				1974 (100 m²)			
	♀♀	☿☿	♂♂	Σ	♀♀	☿☿	♂♂	Σ	♀♀	☿☿	♂♂	Σ
dist	22	202	3	227	13	69	3	85	—	2	1	3
hort	99	2086	18	2203	28	678	17	723	3	18	—	21
hypn	4	4	—	8	—	—	—	—	—	—	—	—
jon	1	2	—	3	—	2	—	2	—	—	—	—
lap	122	131	—	253	8	855	—	863	3	13	3	19
luc	25	4652	12	4689	3	106	—	109	15	430	4	449
pasc	19	876	5	900	29	2006	14	2049	2	40	3	45
prat	2	15	—	17	—	2	—	2	—	—	—	—
rud	2	—	8	10	10	54	17	81	—	13	8	21
sor	—	5	—	5	—	20	—	20	—	—	—	—
vet	7	65	—	72	13	163	—	176	—	—	—	—
total	303	8038	46	8387	104	3955	51	4110	23	516	19	558

Weather conditions

I had at my disposal a Lambrecht-thermo-hygrograph (temperature area +40—0° C, R.H. 0—100 %), which was placed on the ground near the study field (in the shade, in the woods). All temperature and humidity values were taken from the thermohygrograph records. These may not have shown the actual conditions where the bumblebees were. For example, the recorded values present lower temperatures during sunny hours and a higher relative humidity after rain than the actual situation on the field, but the differences are most probably meaningless. Precipitation values were taken from the precipitation meter at the Experiment Station.

The mean temperature, precipitation, num-

Table 2. Mean temperature (°C), precipitation (mm), rain days (precipitation over 1 mm), and mean relatively humidity (%, at 13.00 hrs) in 1972—1974.

	mean temperature °C			precipitation mm			rain days (over 1 mm)			mean R.H. % (at 13.00)		
	1972	1973	1974	1972	1973	1974	1972	1973	1974	1972	1973	1974
15—31 May	9.56	11.99	7.38	21.6	39.1	27.6	5	6	6	65.1	58.8	59.6
1—30 June	15.16	15.56	14.08	46.2	68.3	44.1	9	7	10	58.7	57.3	56.5
1—31 July	18.39	18.52	15.82	45.3	4.1	69.4	9	3	16	60.7	51.4	77.9
1—31 August	16.23	13.75	13.52	138.6	49.6	181.4	17	13	19	79.9	65.7	83.3
whole summer	15.50	15.41	13.70	251.7	161.1	322.5	40	29	51	65.5	58.2	71.1

Table 3. July and August maximum temperature (°C), mean temperature (°C), precipitation (mm), and mean relative humidity (%, at 13.00 hrs) for five-day periods in 1972—1974.

	maximum temperature °C			mean temperature °C			precipitation mm			mean R.H. % (at 13.00)		
	1972	1973	1974	1972	1973	1974	1972	1973	1974	1972	1973	1974
July												
1— 5	28.5	28.0	19.5	21.4	19.7	14.8	0.4	0.0	4.0	55	49	72
6—10	30.5	27.0	26.0	19.4	18.5	17.0	9.8	0.0	14.2	70	43	71
11—15	28.0	27.0	20.5	21.0	18.9	15.5	15.5	1.4	14.6	69	53	79
16—20	26.0	26.5	24.0	17.3	20.8	17.4	1.1	0.3	2.0	60	43	77
21—25	25.0	24.5	21.5	16.0	16.7	17.1	3.0	1.6	17.0	55	69	79
26—31	24.0	26.0	19.0	15.8	16.8	13.6	15.5	1.2	17.6	57	52	88
August												
1— 5	26.5	24.0	20.0	18.2	17.1	14.3	19.0	6.9	41.8	57	60	79
6—10	26.0	27.0	16.5	18.2	15.8	12.2	2.9	10.1	44.0	71	60	91
11—15	20.0	25.0	20.5	13.7	15.2	14.6	58.2	0.2	65.6	89	57	90
16—20	21.5	27.5	18.0	15.2	16.6	13.5	10.5	9.2	15.7	91	54	82
21—25	21.0	13.0	18.0	15.9	9.1	12.6	46.6	14.9	9.6	92	87	77
26—31	—	16.5	21.0	—	8.2	14.0	1.4	8.3	4.7	—	75	81

ber of rainy days, and relative humidity at Karila in the summers 1972—1974 are presented in Table 2, and the five-day weather conditions in July—August of each year in Table 3. In both 1972 and 1973 the summers were exceptionally warm and July 1973 was especially dry (precipitation means of long duration at Karila are: June 57 mm, July 69 mm, and August 73 mm). As a whole, these summers were advantageous for bumblebees and red clover seed yield. On the other hand, summer 1974 was colder than the previous summers and exceptionally wet, particularly the first half of August. Red clover started flowering late and the whole summer was disadvantageous for the pollinators.

Red clover visits by bumblebees

Annual visits

The total numbers of bumblebees seen visiting red clover at Karila were 8387 in 1972, 4110 in 1973, and 558 in 1974 (see Table 1). However, the areas of the fields differed annually, and when the numbers of bumblebees are counted per 100 m², the total numbers are more uniform, although the order remains the same. Comparison with VALLE's results in 1960—1964 (1960 published in VALLE et al. 1960, 1961—1963 in VALLE et al. 1964, 1964 VALLE unpublished) shows that during the years my observations were made the numbers of bumblebees on red clover were lower than in the early 1960's (Table 4).

The percentage proportions of all bumblebee species in 1972—1974 are presented in Fig. 2. There are great variations in the species composition in different summers. *B. lucorum* was clearly the most common species in 1972 and 1974, but rare in 1973. In 1972, *B. hortorum* and *B. pascuorum* were relatively common, in 1973 the two last-mentioned species and *B. lapidarius*, but in 1974 only a few bumblebees were observed apart from *B. lucorum*. However, the flowering season continued into September, when flower visits were not checked. Other red clover visitors worth mentioning are *B. distinguendus*, *B. veteranus*, and *B. ruderarius*, while *B. hypnorum*, *B. jonellus*, *B. pratorum*, and *B. soroeensis* paid only occasional visits. Besides bumblebees some cuckoo bumblebees (*Psithyrus* spp.) visited red clover and, moreover, the number of honeybees was relatively high in 1972—1973.

Table 4. Numbers of bumblebee individuals /100 m²/ observation day on diploid (1960—1964) and tetraploid red clover (1960—1964, 1972—1974). The numbers of bumblebees in 1960—1964 are counted from the results presented by VALLE et al. (1960, 1964) and from VALLE's unpublished results.

	individuals /100 m²/ observation day						
year	luc	dist	hort	lap	pasc	others	total
diploid red clover							
1960	11.38	6.81	14.62	8.10	5.19	0.95	47.05
1961	6.74	3.37	26.63	1.68	22.84	0.53	61.79
1962	15.00	0.50	4.50	1.50	1.00	0.25	22.75
1963	5.58	0.70	6.28	3.95	20.23	0.47	37.21
1964	0.64	0.00	5.53	2.13	10.00	0.00	18.30
tetraploid red clover							
1960	8.52	6.23	17.86	3.62	1.67	0.19	38.09
1961	10.74	2.01	35.63	1.58	2.58	0.02	52.56
1962	11.50	0.63	5.23	1.20	1.38	0.00	19.93
1963	3.14	0.35	11.74	1.16	15.93	0.35	32.67
1964	2.02	0.53	10.74	1.38	1.28	0.00	15.96
1972	12.95	0.66	6.46	0.73	2.58	0.33	23.72
1973	0.55	0.43	3.63	4.36	10.09	1.41	20.47
1974	14.48	0.10	0.68	0.61	1.45	0.68	18.00

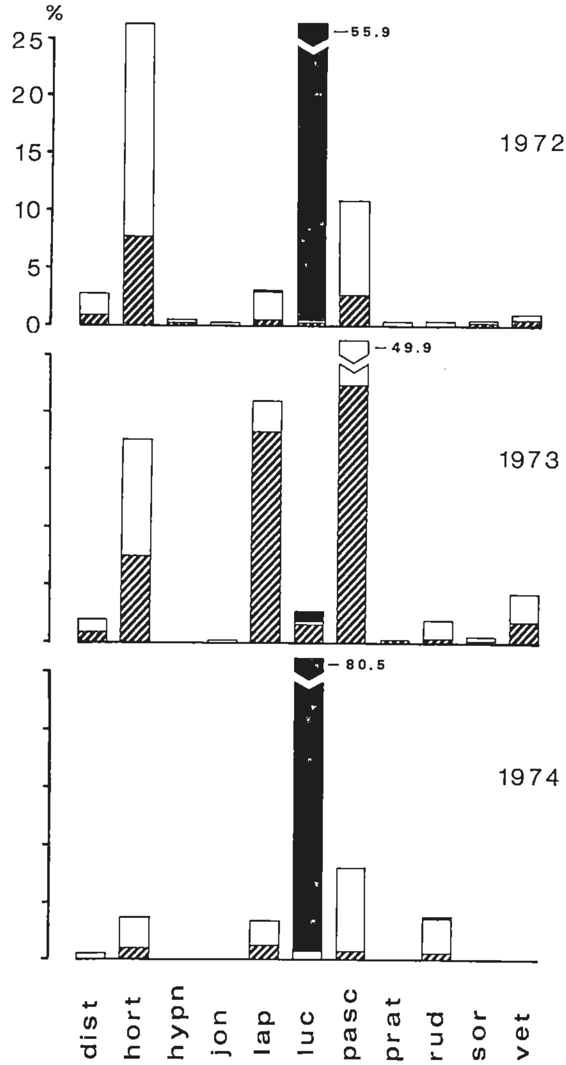

Fig. 2. Distribution of the bumblebee species visiting red clover in 1972—1974. Parts of the columns: hatched = pollen collectors, white = nectar collectors, black = nectar robbers. Numbers of individuals, see Table 1.

B. lucorum, *B. hortorum*, and *B. pascuorum* were the most common species in 1960—1964, too, and many variations in the percentage distribution of bumblebee species were also observed in the early 1960's (Table 4). *B. hortorum* visited tetraploid red clover more than diploid, but other bumblebee species preferred diploid varieties (Table 4). Of the pollinating bumblebees, *B. pascuorum* was the most common in 1963, 1973, and 1974 (on diploid red clover in 1964, too) and *B. hortorum* in other years (Fig. 3). According to MELA (1969), the most common pollinator in 1965 was *B. hortorum* and in 1966 *B. pascuorum*. Moreover, the actual bumblebee numbers per 100 m^2 show that *B. distinguendus* was rare in 1972—1974 compared with 1960—1961, and that the proportion of this species was much lower than in 1960. The abundance of different bumblebee does not seem to depend on the abundance or scarcity of the other species.

Bumblebees seem to prefer the sides of red clover field to the centre of it, since about 60 % of the red clover visitors were observed on the side strips and only 40 % on the centre strip (Fig. 4). This was true of all species. This phenomenon must be explained by a reluctance to expend energy during foraging trips.

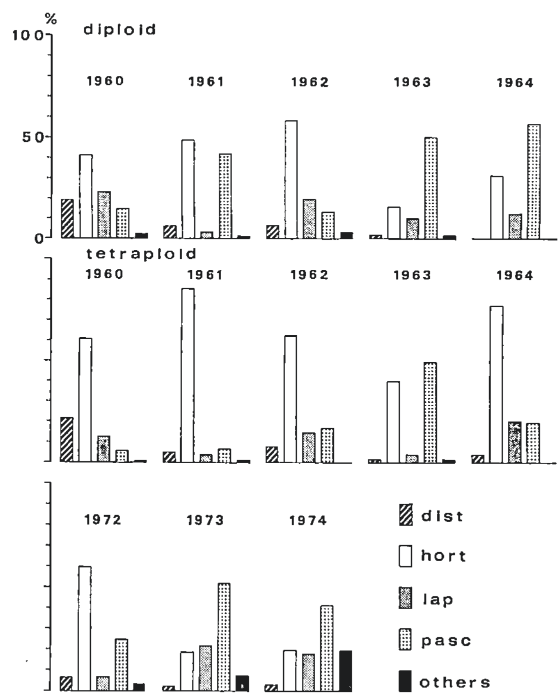

Fig. 3. Distribution of pollinating bumblebee species in 1960—1964 (diploid and tetraploid red clover) and in 1972—1974 (tetraploid red clover). Years 1960—1963 from VALLE et al. (1960, 1964) and 1964 from VALLE's unpublished investigations.

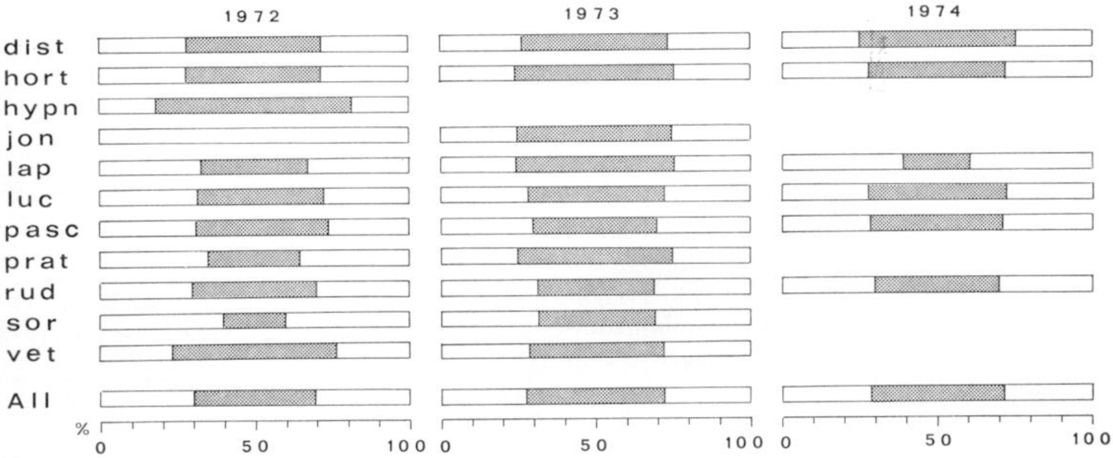

Fig. 4. Distribution of bumb ebee visits at the sides (white area) and in the centre (shaded area) of the red clover field in 1972—1974.

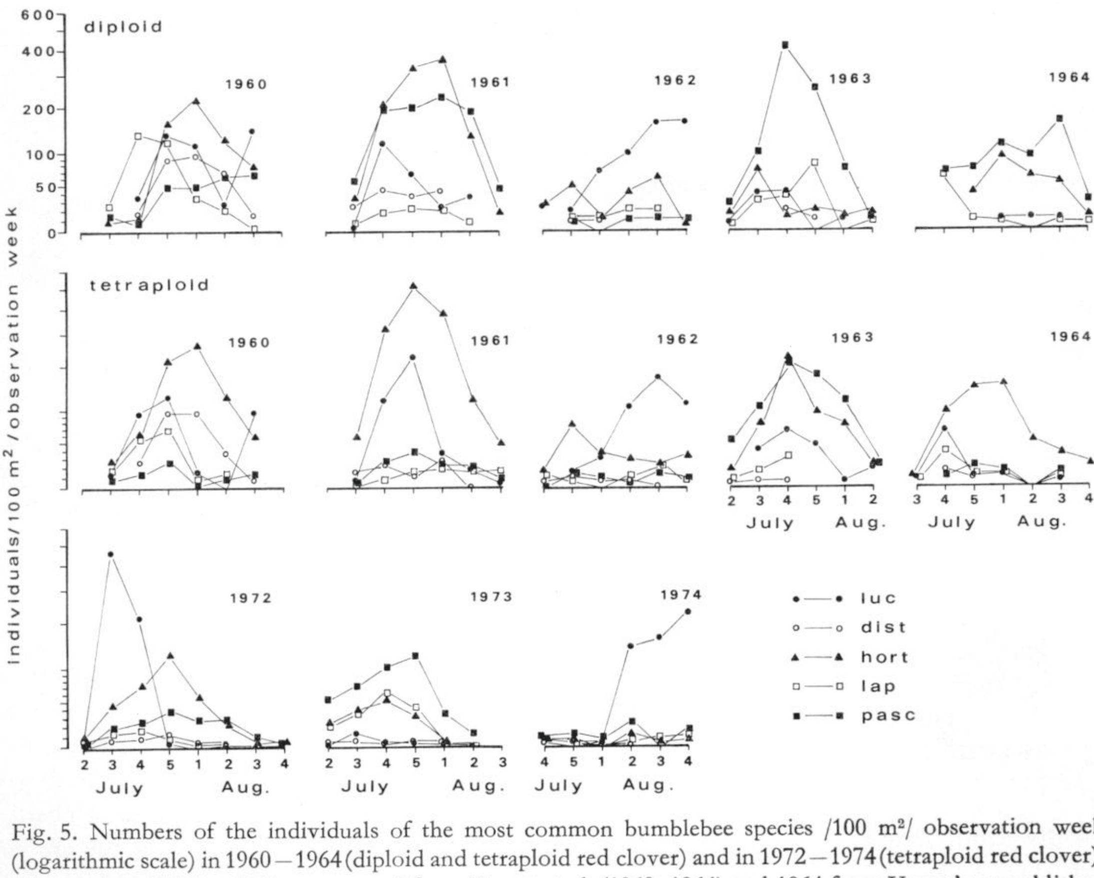

Fig. 5. Numbers of the individuals of the most common bumblebee species /100 m²/ observation week (logarithmic scale) in 1960—1964 (diploid and tetraploid red clover) and in 1972—1974 (tetraploid red clover). The results of 1960—1963 are counted from VALLE et al. (1960, 1964) and 1964 from VALLE's unpublished investigations.

Investigation of the weekly flower visits shows some differences between species in maximum occurence on the red clover field (Fig. 5). *B. lucorum* seems to be the most common visitor to red clover during the first part of the flowering season and visits by *B. hortorum* and *B. pascuorum* reach a maximum about a week later. Of the other species *B. veteranus*, especially, comes to red clover fields late. However, in cool and rainy summers *B. lucorum* make most of its visits late in the season, as can be seen from the observations made in 1962 and 1974.

Daily visits

Bumblebees do not visit flowers regularly throughout the day, but the number of visits reaches a maximum at noon, with somewhat less activity in the morning and in the afternoon and much less in the evening (TERÄS 1976). On red clover fields bumblebees are most numerous at noon and in the afternoon; there are fewer visits in the morning, and only a couple of bumblebees visit red clover at 21 hrs (Fig. 6). All the bumblebee species behave in almost the same way, although some variations between years are possible. Male bumblebees do not visit red clover in the evening, but fly so late in the season that evenings are often too dark for seeking food.

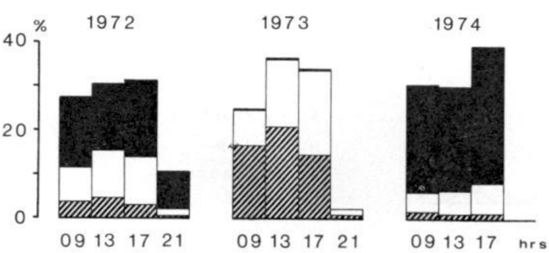

Fig. 6. Distribution of bumblebee visits on red clover at different times of the day in 1972–1974. Parts of them columns: hatched = pollen collectors, white = nectar collectors, black = nectar robbers.

Pollen and nectar collecting

Bumblebees with a positive effect on red clover collect either pollen or nectar or both at the same time during their foraging trips. Pollen collectors work more quickly and therefore pollinate more flowers than nectar collectors (SKOVGAARD 1952). In 1972 and 1974 there were more nectar collectors than pollen collectors at Karila; vice versa in 1973:

year	pollen collectors		nectar collectors	
1972	1015	27.5 %	2679	72.5 %
1973	2182	53.6 %	1892	46.4 %
1974	20	17.9 %	92	82.1 %

The number of pollen collectors always decreased towards the evening (Fig. 6), and the proportion of pollen collectors of all the pollinating bumblebees was (%):

hrs	1972	1973	1974
09	32.4	60.7	25.0
13	29.5	57.5	16.2
17	21.6	43.2	14.0
21	19.1	28.1	—

Robbing

Some bumblebees do not collect nectar in the normal way, through the corolla tube, but rob it by piercing the tube so that the flower remains unpollinated. The most common robber species at Karila was *B. lucorum* (both queens, workers, and males), but some *B. lapidarius* workers robbed in 1972, too. The percentage proportions of robbers and pollinators in 1960–1966, and 1972–1974 are presented in Fig. 7. The reason for the tremendous variations between the years is unknown. However, in 1973 *B. lucorum* was attracted by *Phacelia tanacetifolia* growing near the red clover field. On the other hand, over 70 % of *B. lucorum* individuals had a positive effect on red clover, too, and so the amount of nectar may have been sufficient to make proper pollination possible.

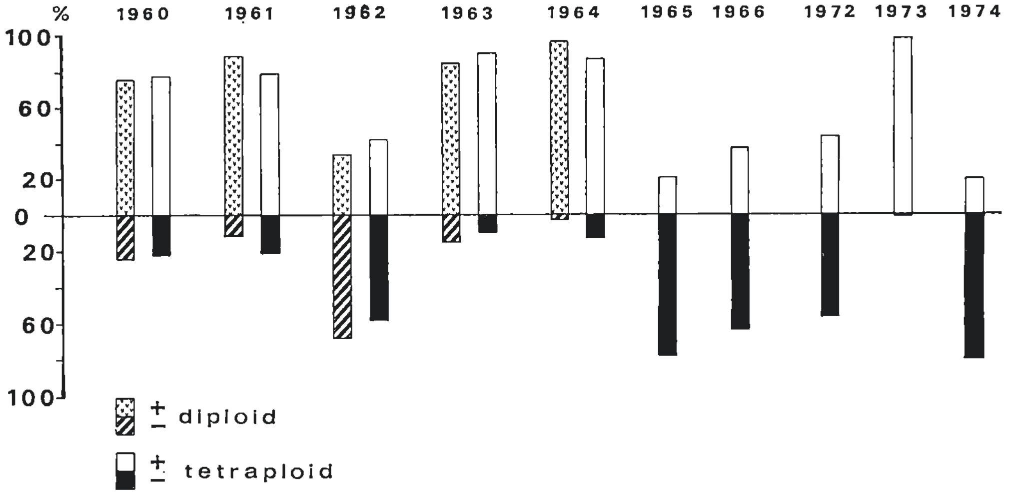

Fig. 7. Distribution of bumblebees working positively (+ = collecting pollen or nectar) or negatively (— = robbing nectar) on diploid and tetraploid red clover in 1960—1966, 1972—1974. Years 1960—1963 from VALLE et al. (1960, 1964), 1964 VALLE unpublished, and 1965—1966 from MELA (1969).

Except during rainy summers, robbing was most common in the beginning of the flowering season. Most robbers were observed at noon.

Bumblebee males as red clover pollinators

Bumblebee males usually prefer composites as food cources (TERÄS 1976). However, some males visit red clover, too. In 1972—1974 the proportion of males visiting red clover was:

1972	0.55 %
1973	1.24 %
1974	3.41 %

B. hortorum, *B. pascuorum*, and *B. ruderarius* males especially seem to visit red clover. Most of *B. lucorum* males robbed nectar from red clover; other species were nectar collectors (for their own use, not for the nest).

Discussion

The best seed yields from red clover are harvested after a warm and dry flowering season, because these are the conditions needed for the seed to ripen and pollination to take place efficiently. Also nectar production and sugar concentration are greatest on sunny days (BOHART 1957, PAATELA and HEINRICHS 1959), and so pollinators are best attracted. Bumblebees are ideal red clover pollinators, although their populations are unpredictable and usually unsufficient (BOHART 1957). Tetraploid red clover, which has a corolla tube about 1 mm longer than the diploid variety (PAATELA 1962, HOLM 1966) demands long-tongued bumblebees for pollination.

The numbers of bumblebee populations vary greatly from year to year. SKOVGAARD (1952) considers that the numbers of all bumblebees are decreasing and my results indicate that this is so, when the numbers of bumblebees observed in 1972—1974 are compared with those in 1960—1961. Some of the differences between the above years may be due to different counting methods: VALLE (see VALLE et al. 1960) used areas of 10 or 25 m^2 and multiplied the numbers of bumblebees observed by 10 or 4, respectively, to get the numbers per 100 m^2, while I used line countings of at least 100 m^2. VALLE counted bumblebees only once a day while I had three or four countings. Moreover, VALLE used some very restricted red clover plots where populations must have been dense (see also my observations in 1974 compared with the results of the two previous years). On the other hand, VALLE counted bumblebees every day during the red clover flowering season, while I counted only twice a week, and if the weather was poor on my counting days I had lower numbers of visitors, too. In all, the numbers of bumblebee visitors in 1960—1964 given by VALLE may be a little higher than the actual numbers and in my results, on the other hand, the numbers may be a little too low. Anyway, I think that the numbers of bumblebees at Karila have, in fact, decreased since the early 1960's.

The percentage proportions of different bumblebee species vary greatly from year to year and this may be due to weather conditions at the nest foundering time or foraging time (FRIDÉN et al. 1962, HOLM 1966), lack of suitable food plants, or, as far as red clover is concerned, competition from other flowers. BINGEFORS et al. (1960) and HÄNNINEN (1962) have noticed that when *B. lapidarius* is common, *B. pascuorum* is scarce and vice versa, but I could not observe any interspecific competition between these or any other species. At Karila, *B. lucorum* had the greatest fluctuations; the same phenomenon was observed by VALLE et al. (1962) near Helsinki and by HÄNNINEN (1962) in Central Finland.

On red clover, the most common bumblebees were *B. lucorum*, *B. pascuorum*, and *B. hortorum*, in that order. The two last-mentioned species were the most efficient pollinators, as previously (VALLE et al. 1960, 1964, MELA 1969), and as they are elsewhere in Central Finland (HÄNNINEN 1962). However, beyond the red clover fields the most common species was *B. pascuorum*, which is numerous on natural fields in South Savo (see TERÄS 1976). *B. lapidarius* and *B. distinguendus* were not as common as they are in southern Finland (VALLE 1959, VALLE et al. 1964). *B. hortorum* is especially important to the pollination of tetraploid red clover because of its long tongue and efficient working speed (HÄNNINEN 1962), and it was the only species which was clearly more numerous on tetraploid than diploid red clover. *B. hortorum* was scarce in the area surrounding the station as was *B. distinguendus*. According to HÄNNINEN (1962) and LØKEN (1962) *B. hypnorum*, *B. jonellus*, *B. pratorum*, and *B. soroeensis* are not important as red clover pollinators because they prefer other plant species, and this was easily noticed at Karila, too.

Bumblebees need both pollen and nectar to feed their larvae. Red clover is a good nectar source and an excellent pollen source (at least for honeybees, BOHART 1957). In 1972 and 1974 the number of nectar collectors was higher than that of pollen collectors, probably because the latter work more quickly (SKOVGAARD 1952) so that sufficient pollen can be collected by fewer workers. In 1973 the situation was, however, reversed, but because the summer was warm and dry, the nectar must have had a high sugar concentration and the needs of the bumblebee colonies were satisfied with less effort. On the other hand, the large number of nectar collectors in 1974 would indicate that the nectar was diluted. The reason for the diurnal variations in feeding habits may be almost the same, that is to say nectar is collected more often in the evening because there is more of it (produced during the warmest hours of the days). According to SKOVGAARD (1952) nectar collectors are quicker than pollen collectors in late summer, when the bumblebees are bigger. However, at Karila pollen and nectar were collected almost at the same rate through the summer.

B. lucorum is known as a regular robber bumblebee (KORCKMAN 1938, VALLE 1948, 1955, 1959, VALLE et al. 1960, 1964, HÄNNINEN 1962, MELA 1969). Other red clover robbers are *B. lapidarius*, especially small workers (KORCKMAN 1938, HÄNNINEN 1962, LØKEN 1962), and *B. jonellus* (KORCKMAN 1938, VALLE et al. 1960). However, robbing is not always detrimental to pollination (HOLM 1966). Tetraploid red clover is said to be robbed more often than diploid (FRIDÉN et al. 1962, VESTAD 1962, DENNIS and HAAS 1967), but in 1960—1964 no such trend was evident at Karila. FRIDÉN et al. (1962) and SCHWAN (1962) say that bumblebees rob most at the end of the summer, but according to VALLE (1959) the robbers come first and then the pollinators, and KORCKMAN (1938) tells that *B. lapidarius* robbed only at the beginning of the summer but pollinated all summer. At Karila, *B. lucorum* was an eager robber throughout the season but paid the maximum number of visits during the first half of the red flowering season except in rainy summers, when the maximum was reached later. Robbing *B. lapidarius* workers were observed in late July.

According to KORCKMAN (1938) bumblebee males play no significant part in red clover pollination. The same observation was made by TERÄS (1976), with diploid red clover again, and the present results with tetraploid red clover show that the contribution of bumblebee males as red clover pollinators is small but not meaningless in South Savo.

Besides bumblebees, cuckoo bumblebees and honeybees also pollinated red clover. Cuckoo bumblebees are not important pollinators because they are rare and are slow workers. On the other hand, honeybees are said to be good red clover pollinators during fine weather (HOLM 1966), and important pollinators, for example, in Denmark (DENNIS and HAAS 1967), Norway (VESTAD 1962) and even in southern parts of Finland (VALLE 1959). However, in Savo honeybees are of minor significance as red clover pollinators (VALLE et al. 1964, VALLE 1966).

The best seed yields ever reaped at Karila were harvested in 1973. The weather was warm and dry for a long time in July, pollinators (*B. pascuorum, B. lapidarius, B. hortorum*) were numerous and practically no robbers were observed. *B. lucorum* found competing plants, especially *Phacelia tanacetifolia*, more attractive than red clover, and it is possible that some competing plants may be useful in drawing robbers from the red clover fields. However, there must have been a great deal of nectar in 1973 because of the sunny weather and that is probably why even *B. lucorum* did a lot of pollinating.

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Ilkka Teräs
Department of Zoology
Division of Morphology and Ecology
University of Helsinki
P. Rautatiekatu 13
SF-00100 Helsinki 10, Finland

SELOSTUS

Kimalaisten käynnit puna-apilan kukissa Etelä-Savossa

Ilkka Teräs

Helsingin Yliopisto

Kimalaisten käyntejä tetraploidin puna-apilan kukissa tutkittiin kesinä 1972—74 Etelä-Savon koeasemalla Karilassa (Mikkelin mlk). Kimalaisyksilöt laskettiin linja-arviomenetelmällä kolme—neljä kertaa päivässä kahdesti viikossa koko puna-apilan kukinta-ajan. Tutkittujen yksilöiden määritys tehtiin värituntomerkkien perusteella kimalaisia kiinniottamatta. Myös ravinnonkeruutapa merkittiin muistiin. Saatuja tuloksia on verrattu aikaisemmin samalla paikalla tehtyihin kimalaistutkimuksiin vuosilta 1960—66 (Valle ym. 1960, 1964, Valle julkaisematon, Mela 1969).

Tutkimuspelloilla tavattiin 11 kimalaislajia v. 1972, 10 lajia v. 1973 ja 6 lajia v. 1974. Yleisimmät lajit olivat mantukimalainen (*Bombus lucorum*), tarhakimalainen (*B. hortorum*), peltokimalainen (*B. pascuorum*) ja kivikkokimalainen (*B. lapidarius*), kesinä 1972—73 myös kirjokimalainen (*B. distinguendus*) ja hevoskimalainen (*B. veteranus*) esiintyivät melko runsaina. Ympäröivillä luonnonniityillä ja puutarhassa yleiset kartanokimalainen (*B. hypnorum*) ja niittykimalainen (*B. pratorum*) eivät muutamaa poikkeusta lukuunottamatta käyneet puna-apilan kukissa.

Kesällä 1972 kimalaisista 56 % oli mettä ryöstäviä mantukimalaisia ja kesällä 1974 mantukimalaisten osuus oli peräti 81 %, sen sijaan kesällä 1973 runsaslukuisimpina esiintyivät pölyttävät tarha-, pelto- ja kivikkokimalaiset, kun taas mantukimalaiset kävivät lähipellolla kasvavan hunajakukan (*Phacelia tanacetifolia*) kukissa. 1960-luvun alun kimalaismääriin verrattuna kokonaisluku pinta-alayksikköä kohti oli laskenut ja varsinkin kirjokimalainen oli harvinaistunut. Lajisuhteet ja medenryöstäjien määrä vaihtelivat säännöttömästi.

Lämpiminä kesinä mantukimalaiset kävivät puna-apilassa runsaimmin kasvukauden alussa, pitkäkieliset lajit taas vilkkaimmin viikkoa myöhemmin, mutta sateisena kesänä 1974 kimalaismäärät olivat huipussaan vasta puna-apilan kukinnan loppupuolella elokuun viimeisinä viikkoina. Vuorokautisten käyntien huippu osui keski- tai iltapäivään, mutta myös aamulla pelloilla oli runsaasti kimalaisia, sen sijaan illalla käynnit loppuivat yleensä ennen klo 21. Kimalaiset kävivät enemmän pellonreunan kukissa kuin keskustassa.

Medenryöstäjinä olivat ennen kaikkea mantukimalaiset, myös jotkut kivikkokimalaistyöläiset ryöstivät. Ryöstäminen ajoittui iltapäivään. Muut lajit pölyttivät puna-apilaa joko siitepölyä tai mettä keräämällä tai molemmin tavoin. Medenkerääjien osuus lisääntyi aina iltaa kohti. Siitepölynkerääjiä oli enemmän kuin medenkerääjiä vain lämpimänä kesänä 1973, jolloin yhteiskuntien medentarve tuli ilmeisesti tyydytettyä vähemmällä työllä. Puna-apilassa kävijöitä olivat ennen kaikkea työläiset ja kuningattaret, koiraiden osuus oli vain 0.6—3.4 %.

Puna-apilan siemensato oli vuonna 1972 keskinkertainen (350 kg/ha), vuonna 1973 erittäin hyvä (yli 700 kg/ha) ja vuonna 1974 lähes olematon huonojen kasvuolojen ja vähäisten pölyttäjämäärien takia.

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Seria ANIMALIA NOCENTIA N. 88 — Sarja TUHOELÄIMET n:o 88

IDENTIFICATION KEY TO FINNISH MOSQUITO LARVAE (DIPTERA, CULICIDAE)

PIRKKA UTRIO

UTRIO, P. 1976. **Identification key to Finnish mosquito larvae (Diptera, Culicidae).** Ann. Agric. Fenn. 15: 128—136. (Dept. Virology, Univ. Helsinki, Haartmaninkatu 3, SF-00290 Helsinki 29, Finland).

The IV instar larvae of Finnish mosquitoes are classified according to genera and species; most of them are illustrated from Finnish specimens. Altogether 36 species are included, of which *Aedes punctodes* Dyar and *Culiseta silvestris ochroptera* (Peus) are reported as new to Finland.

Index words: *Culicidae*, mosquito larvae, key.

Introduction

Apart from the nuisance they cause, mosquitoes have been found to be vectors of arboviruses widespread among man, cattle and wildlife in Finland (see BRUMMER-KORVENKONTIO and SAIKKU 1975). However, knowledge about Finnish mosquitoes is still far from adequate, and much more information is needed to obtain a clear picture of the ecology and distribution of these insects. The larval stage is very suitable for the study of mosquito distribution, since most of the larvae are readily identified (unlike females), and large samples are easily obtained (unlike males).

In the present paper the IV instar larvae of Finnish mosquitoes are classified according to genera and species. A few species have been found only in adult stage in Finland; these are included in the key on the bases of foreign descriptions, mainly those of NATVIG (1948), MOHRIG (1969) and GUTSEVICH et al. (1974). The nomenclature follows the catalogues composed by STONE et al. (1959) and STONE (1967). Only synonyms which appear as valid names in the reference papers are given.

As far as it is known, regional distribution in Finland of each species is given according to the available literature (FREY 1921, NATVIG 1948, TIENSUU 1951, 1952, HIRVENOJA 1961, 1962, 1967, KOSTAMA 1964, BRUMMER-KORVENKONTIO et al. 1971, ULMANEN and BRUMMER-KORVENKONTIO 1971, UTRIO 1975), and on the bases of collections in the Department of Virology and Zoological Museum, University of Helsinki. In this connection, the following arbitrary designations are used: South Finland 60°—62° N, Central Finland 62°—64° N, North Finland 64°—66° N, South Lapland 66°—68° N, and North Lapland 68°—70° N. A more detailed account

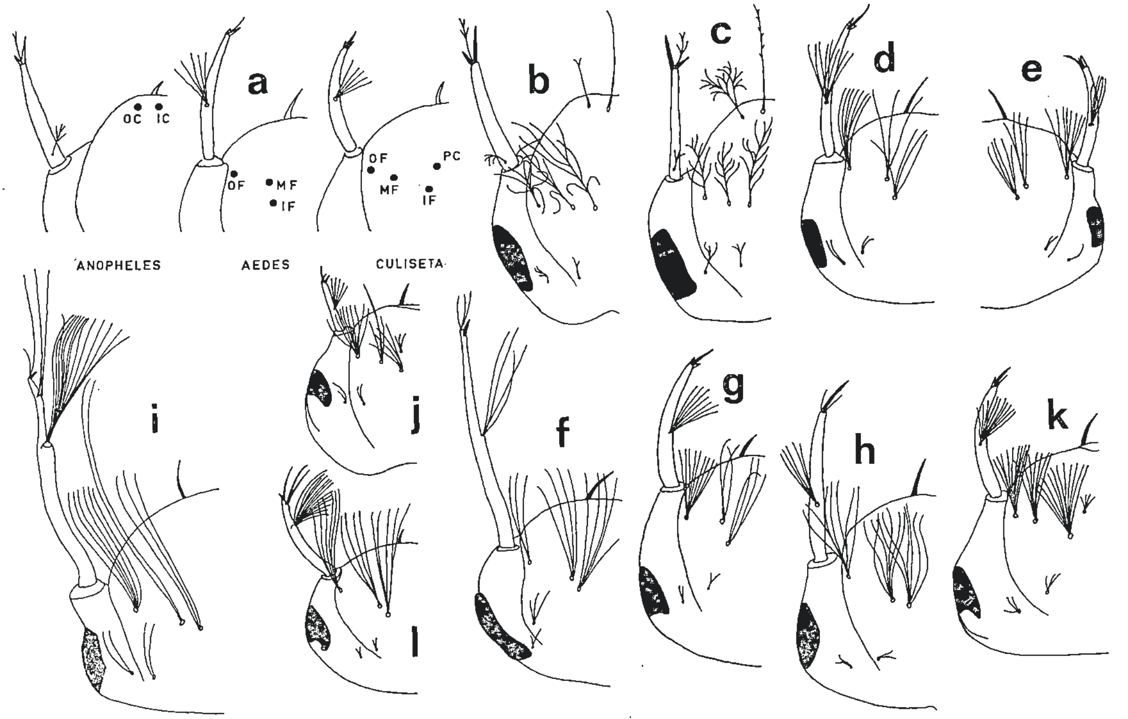

Fig. 1. Heads of mosquito larvae, dorsal view. — a, Situations of the main hair groups: OC, outer clypeal; IC, inner clypeal; PC, postclypeal; OF, outer frontal; MF, midfrontal; IF, inner frontal — b, *Anopheles claviger*. — c, *A. maculipennis*-group. — d, *Aedes pionips*. — e, *A. pullatus*. — f, *A. diantaeus*. — g, *A. vexans*. — h, *A. cinereus*. — i, *Culiseta morsitans*. — j, *C. annulata*. — k, *C. bergrothi*. — l, *Culex pipiens*.

on the distribution of Finnish mosquitoes will be published in the future.

The terminology concerning diagnostic morphological charasteristics applied in the key is given in Fig. 1—2. The size and color of mosquito larvae are very variable within one species; hence these characteristics are omitted in the key.

Key to the genera

1 (2) Siphon absent (Fig. 2n) .... 1. *Anopheles*
2 (1) Siphon present (Fig. 2a—m, 3a—l)
3 (4) Siphon asymmetric in lateral view (Fig. 2b) .... 2. *Mansonia*
4 (3) Siphon cylindrical (Fig. 2a, c—m, 3a—l)
5 (8) Siphon with one pair of siphonal tufts (Fig. 2c—l, 3a—l)
6 (7) Siphonal tufts situated in the mid region of the siphon (Fig. 2c—l, 3a—i) ...... 3. *Aedes*
7 (6) Siphonal tufts situated at base of the siphon (Fig. 3j—l) .... 4. *Culiseta*
8 (5) Siphon with several pairs of siphonal tufts (Fig. 2m) .... 5. *Culex*

Key to the species

1. *Anopheles*

1 (2) Outer and inner clypeal hairs simple or with 2—4 branches in their apical portions (Fig. 1b) .... *A. claviger*
2 (1) Outer clypeal hairs richly branched near the base, bush-shaped; inner clypeal hairs richly branched in their apical portions or with short branches along the stems (Fig. 1c). .... *A. maculipennis* — group

2. *Mansonia*

Only one species in Finland, *M. richiardii* (Fig. 2b).

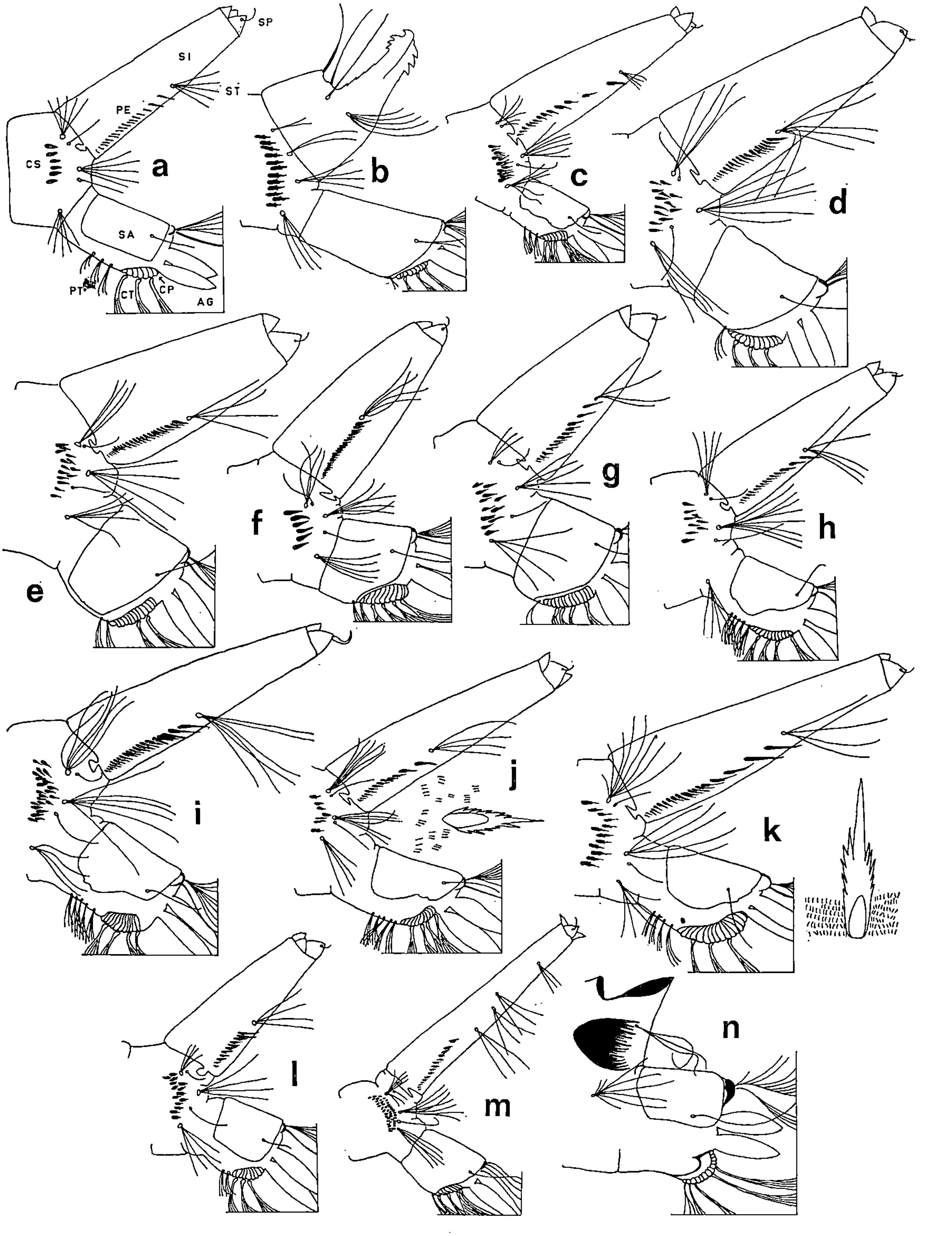

Fig. 2. Terminal segments of mosquito larvae, lateral view. — a, *Aedes*, schematic: AG, anal gills; CS, comb scales; CT, cratal tufts; CP, cratal plate; PE, pecten; PT, precratal tufts; SA, saddle; SI, siphon; SP, stigmal plate; ST, siphonac tuft. — b, *Mansonia richiardii*. — c, *Aedes cinereus*. — d, *A. punctor*. — e, *A. punctodes*. — f, *A. hexodontus*. — g, *A. nigripes*. — h, *A. diantaeus*. — i, *A. excrucians*. — j, *A. riparius*, with a comb scale and surface spines. — k, *A. cyprius*, with a comb scale and surface spines. — l, *A. impiger*. — m, *Culex pipiens*. — n, *Anopheles claviger*.

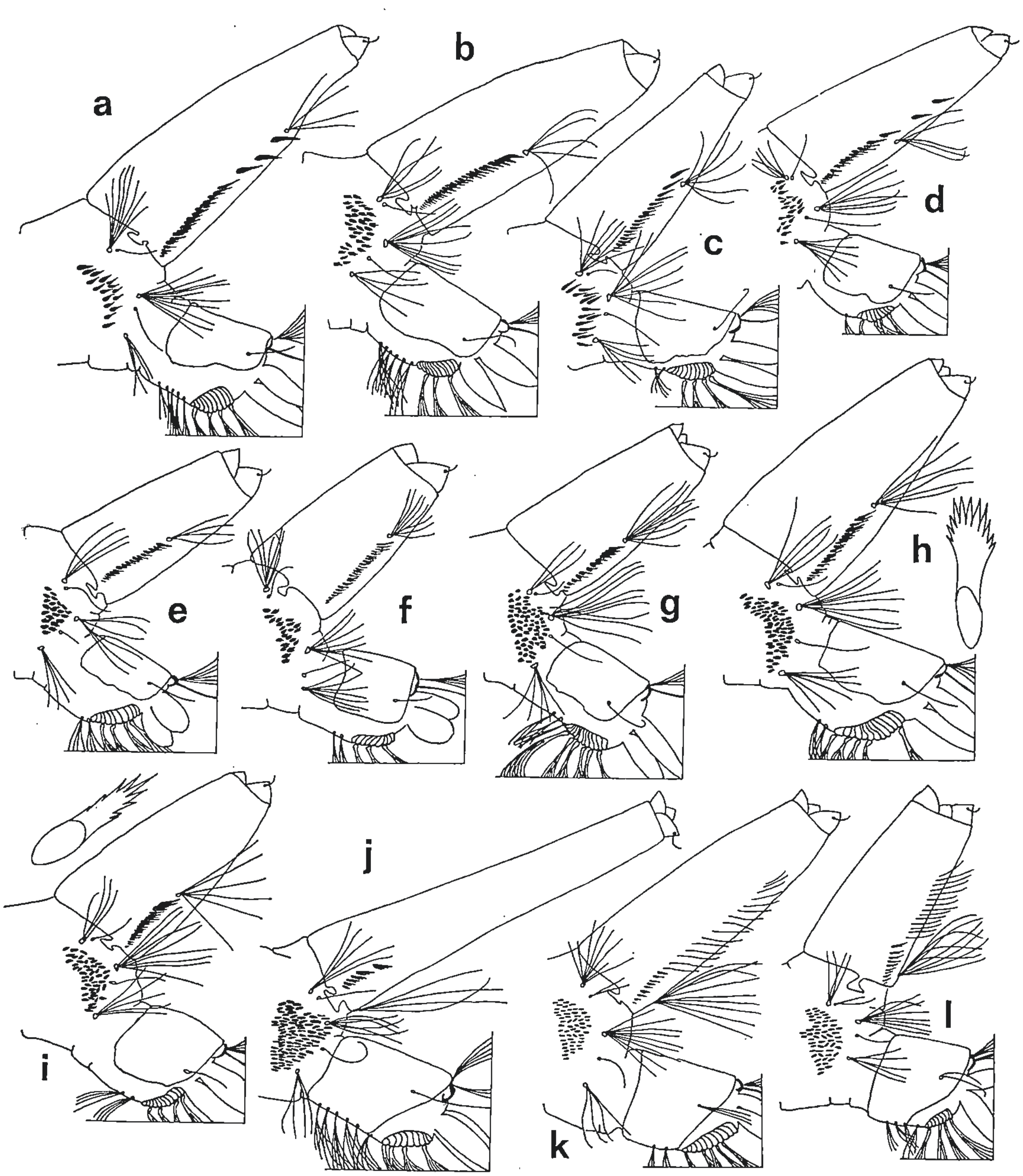

Fig. 3. Terminal segments of mosquito larvae, lateral view. — a, *Aedes beklemishevi*. — b, *A. cantans*. — c, *A. intrudens*. — d, *A. cataphylla*. — e, *A. dorsalis* — f, *A. caspius*. — g, *A. communis*. — h, *A. pionips*, with a comb scale. — i, *A. pullatus*, with a comb scale. — j, *Culiseta morsitans*. — k, *C. annulata*. — l, *C. alaskaensis*.

3. Aedes

1 (2) Antennae distinctly longer than the head, with 3 apical spines of about equal length (Fig. 1f) .... *A. diantaeus*

2 (1) Antennae shorter than the head, with one apical spine longer than the others (Fig. 1d–e, g–h)

3 (6) Siphonal tuft small, shorter than the width of the siphon in the insertion region (Fig. 2c)

4 (5) Outer, mid and inner frontal hairs situated in a line, forming a curved row across the head (Fig. 1h). Pecten teeth with 1–2 basal denticles .... *A. cinereus*

5 (4) Inner frontal hairs situated obliquely behind the midfrontal hairs (Fig. 1g). Pecten teeth with 3—5 basal denticles .... *A. vexans*

6 (3) Siphonal tuft large, about as long or longer than the width of the siphon in the insertion region (Fig. 2d—l, 3a—i)

7 (14) Saddle ring-shaped, surrounding the anal segment completely or leaving only a narrow slit uncovered in the ventral midline (Fig. 2d—g)

8 (9) 1—3 distal pecten teeth more widely spaced than the others (Fig. 2g) .... *A. nigripes*

9 (8) Pecten teeth evenly spaced, close together (Fig. 2d—f)

10 (11) Number of comb scales 6—9, scales larger (Fig. 2f) .... *A. hexodontus*

11 (10) Number of comb scales 10—30, scales smaller (Fig. 2d—e)

12 (13) Saddle surrounding the anal segment completely, at least in its anterior part (Fig. 2d). Inner and midfrontal hairs with 1—3 branches .... *A. punctor*

13 (12) Saddle not surrounding the anal segment completely but leaving a narrow slit uncovered in the ventral midline (Fig. 2e). Inner and midfrontal hairs simple .... *A. punctodes*

14 (7) Saddle plate-shaped, leaving the ventral part of the anal segment uncovered (Fig. 2h—l, 3a—i)

15 (28) Number of precratal tufts 4—7 (Fig. 2h—k, 3a—b)

16 (17) Hairs in the ventral valves of the stigmal plate thick, hooks-haped (Fig. 2i) *A. excrucians*

17 (16) Hairs in the ventral valves of the stigmal plate thin, evenly curved (Fig. 2j—k, 3a—b)

18 (25) 1—5 distal pecten teeth more widely spaced than the others (Fig. 2j—k, 3a)

19 (20) Body surface in the comb area tightly covered with small spines arranged in long rows (Fig. 2k) .... *A. cyprius*

20 (19) Body surface in the comb area sparsely covered with small spines arranged in groups of 2—5 (Fig. 2j)

21 (22) Number of comb scales 6—9 (Fig. 2j) .... *A. riparius*

22 (21) Number of comb scales 14—40 (Fig. 3a)

23 (24) Siphonal tuft and the distal pecten tooth situated well above the middle of the siphon (Fig. 3a) .... *A. beklemishevi*

24 (23) Siphonal tuft and the distal pecten tooth situated in the middle of the siphon .... *A. flavescens*

25 (18) Pecten teeth evenly spaced, close together (Fig. 3b)

26 (27) Inner and midfrontal hairs with 2—4 branches .... *A. cantans*

27 (26) Inner and midfrontal hairs simple *A. nigrinus*

28 (15) Number of precratal tufts 1—3 (Fig. 2l, 3c—i)

29 (32) 1—4 distal pecten teeth more widely spaced than the others (Fig. 3c—d)

30 (31) Inner and midfrontal hairs simple. 2—4 distal pecten teeth situated above the siphonal tuft (Fig. 3d) .... *A. cataphylla*

31 (30) Inner and midfrontal hairs with 3—5 branches. 1 or none of the distal pecten teeth situated above the siphonal tuft (Fig. 3c) *A. intrudens*

32 (29) Pecten teeth evenly spaced, close together (Fig. 2l, 3e—i)

33 (38) Anal gills shorter than the saddle (Fig. 3e—f)

34 (35) Spines in the ventral side of the antenna arranged in rows. Pecten teeth with one big basal denticle. The common shaft of each cratal tuft longer than the ridges in the middle of the cratal plate .... *A. leucomelas*

35 (34) Spines in the ventral side of the antenna not arranged in rows. Pecten teeth with 2—4 small basal denticles. The common shaft of each cratal tuft about as long as the ridges in the middle of the cratal plate

36 (37) Siphonal tuft with 3—5 branches, situated in the middle of the siphon (Fig. 3e) *A. dorsalis*

37 (36) Siphonal tuft with 5—10 branches, situated above the middle of the siphon (Fig. 3f) .... *A. caspius*

38 (33) Anal gills longer than the saddle (Fig. 2l, 3g—i)

39 (42) Inner and midfrontal hairs simple (rarely 1 or 2 is bifurcated)

40 (41) Number of comb scales 7—16, scales pointed (Fig. 2l) .... *A. impiger*

41 (40) Number of comb scales 40—80, scales blunt-ended (Fig. 3g) .... *A. communis*

42 (39) Inner and midfrontal hairs with 3—5 branches (Fig. 1d—e)

43 (44) Antennae about 2/3 as long as the head (Fig. 2d). Comb scales blunt-ended, with margin of several spines of equal length (Fig. 3h) .... *A. pionips*

44 (43) Antennae about half as long as the head (Fig. 1e). Comb scales elongated, many of them bearing a midspine distinctly longer than other spines (Fig. 3i) .... *A. pullatus*

4. *Culiseta*

1 (4) Siphon long, about 5 times as long as width at base (Fig. 3j). Antennae distinctly longer than the head (Fig. 1i)

2 (3) Inner frontal hairs with 2—3 branches (Fig. 1i). Comb scales without dark longitudinal midridge .... *C. morsitans*

3 (2) Inner frontal hairs with 5–9 branches. Comb scales in the posterior margin of the comb with dark longitudinal midridges .... *C. silvestris ochroptera*

4 (1) Siphon shorter, about 2.5–3.5 times as long as width at base (Fig. 3k–l). Antennae shorter than the head (Fig. 1j–k)

5 (6) Antennae more than half as long as the head. Midfrontal hairs with 5–9, inner frontal hairs with 9–13 branches (Fig. 1k) .... *C. bergrothi*

6 (5) Antennae shorter than half of the length of the head. Midfrontal hairs with 2–3, inner frontal hairs with 4–8 bransches (Fig. 1j)

7 (8) Number of precratal tufts 4. Siphon about 2.5 times as long as width at base (Fig. 3l) .... *C. alaskaensis*

8 (7) Number of precratal tufts 2–3. Siphon about 3.5 times as long as width at base (Fig. 3k)

9 (10) Distance between the postclypeal hairs as long as the distance between the inner frontal hairs (Fig. 1j) .... *C. annulata*

10 (9) Distance between the postclypeal hairs shorter than the distance between the inner frontal hairs .... *C. subochrea*

5. *Culex*

1 (2) Siphon slightly expanded at apex. Inner and midfrontal hairs with 1–2 branches .... *C. territans*

2 (1) Siphon tapering towards the apex (Fig. 2m). Midfrontal hairs with 2–7, inner frontal hairs with 4–8 branches (Fig. 1l)

3 (4) Siphon about 6 times as long as width at base. The distal siphonal tuft situated more laterally than the others ...... *C. torrentium*

4 (3) Siphon about 5–5.5 times as long as width at base. Siphonal tuft next to the distal one situated more laterally than the others (Fig. 3m) .... *C. pipiens*

Short comments on the biology and distribution of Finnish species

1. *Anopheles* Meigen

Larvae of *Anopheles* occur in varying kinds of permanent or semipermanent bodies of water. The eggs of the *A. maculipennis*-group are deposited by hibernating females. *A. claviger* hibernates as larva.

A. claviger (Meigen)
Found in one locality in South Finland. Palaearctic.

A. maculipennis-group
The group includes several species and subspecies which cannot be identified at larval stage. Mosquitoes belonging to this group occur in whole country. So far, the presence of two species, *A. messeae messeae* Falleroni and *A. maculipennis* Meigen s. str. has been verified in Finland; both are palaearctic.

2. *Mansonia* Blanchard

Larvae of *Mansonia* live as submerged in permanent bodies of water. They obtain their respiratory air from roots and stems of aquatic vegetation. Hibernation occurs as larva.

M. richiardii (Ficalbi)
Found a few times in South Finland. Palaearctic.

3. *Aedes* Meigen

Larvae of *Aedes* usually occur in small bodies of water, especially in temporary or semitemporary pools receiving water from melting snow. The hibernated eggs hatch in spring, and most species attain instar IV in late spring or early summer. Many species have another, though less prominent period of emergence in late summer or autumn.

A. beklemishevi Denisova
Synonyms: *A. grandilarva* Sazonova, *A. barri* Krueger. Found in one locality in North Lapland. Holarctic.

A. cantans (Meigen)
Synonym: *A. maculatus* (Meigen). Common in South Finland, rare in Central and North Finland. Palaearctic. See also under *A. flavescens*.

A. caspius (Pallas)
In South Finland, fairly common. Palaearctic.

A. cataphylla Dyar
In South Finland, uncommon. Holarctic.

A. cinereus Meigen
In whole country and fairly common. Holartic.

A. communis (DeGeer)
In whole country and very common. Holartic.

A. cyprius Ludlow
Synonym: *A. freyi* Edwards. A rare species in South Finland, found once in Central Finland. Palaearctic.

A. diantaeus Howard, Dyar & Knab
In whole country, uncommon in south, fairly common in north. Holartic.

A. dorsalis (Meigen)
Uncommon in South Finland, also recorded once in Central Finland. Holarctic.

A. excrucians (Walker)
In whole country and fairly common. Holarctic.

A. flavescens (Müller)
Synonym: *A. lutescens* (Fabricius). Larva not found in Finland, but adults recorded a few times in South Finland. Holarctic. According to MOHRIG (1969), the pecten teeth of *A. flavescens* may sometimes be evenly spaced so that it keys out as *A. cantans*. However, the number of comb scales is usually less than 30 in *A. flavescens*, and more than 30 in *A. cantans*.

A. hexodontus Dyar
Common in North Lapland, fairly common in South Lapland and North Finland, very rare in Central Finland and found once in South Finland. Holarctic.

A. impiger (Walker)
Synonyms: *A. nearcticus* Dyar, *A. parvulus* Edwards. Found in a few localities in North Finland, South Lapland and North Lapland; in addition, there is an isolated record from South Finland. Holarctic.

A. intrudens Dyar
In whole country, fairly common. Holarctic.

A. leucomelas (Meigen)
Larva not found in Finland, but one adult recorded in South Finland. Palaearctic.

A. nigrinus (Eckstein)
Larva not found in Finland, but two adults recorded in North Lapland. Palaearctic.

A. nigripes (Zetterstedt)
Synonym: *A. alpinus* (Linnaeus). Found in one locality in North Lapland. Holarctic.

A. pionips Dyar
Fairly common in Lapland and North Finland, very rare in Central Finland. Holartic.

A. pullatus (Coquillett)
Found in a few localities in North Lapland; in addition, there is an isolated record from Central Finland. Holarctic.

A. punctodes Dyar
Found in North Finland and South Lapland; reported here as new to the country. Record data: Kn, Kuhmo, Porkkajärvi, 708:60, 12. VI. 1974, 1 larva (author leg.), and KemL, Pelkosenniemi, Komovaara, 746:51, 15. VI. 1974, 1 larva (author leg.). Holartic. Very similar to *A. punctor*, for further details see KNIGHT (1951) and DAHL (1974).

A. punctor (Kirby)
In whole country and very common. Holartic.

A. riparius Dyar & Knab
A rare species, but recorded from South Finland to North Lapland. Holarctic.

A. vexans (Meigen)
Found a few times in South Finland. Cosmopolitan.

4. *Culiseta* Felt

Larvae of most species of *Culiseta* occur in permanent pools and ponds which do not dry up in the summer, and most of the Finnish species hibernate as adults. *C. morsitans* hibernates as larva and occurs together with larvae of *Aedes* in spring pools.

C. alaskaensis (Ludlow)
In whole country, but rarely found as larva. Holartic.

C. annulata (Schrank)
Recorded in two localities in South Finland. Palaearctic.

C. bergrothi (Edwards)
In whole country, but rarely found as larva. Palaearctic.

C. morsitans (Theobald)
Common in South Finland, rare in Central Finland. Holartic.

C. silvestris ochroptera (Peus)
Larva not found in this country, but one adult recorded in South Finland, reported here as new to the country. Record data: U, Tammisaari r. c., Tvärminne Zool. St., 664:28, 22—23. IV. 1975, 1 female (M. Brummer-Korvenkontio leg.). Palaearctic. Very similar to *C. morsitans*, for further details see PEUS (1935).

C. subochrea (Edwards)
Larva not found in Finland, but adults recorded in two localities in South Finland. Palaearctic.

5. *Culex* Linnaeus

Larvae of *Culex* occur in many kind of pools; they are often found in artificial reservoires. Hibernation occurs at adult stage, and there are two, maybe three generations per year.

C. pipiens Linnaeus

C. pipiens pipiens Linnaeus is common in South and Central Finland. Holarctic. *C. pipiens molestus* Forskål is an antropophilous variety of polyphyletic origin (see e.g. BARR 1967), which breeds especially in urban surroundings; it has been recorded in the larger cities of South Finland. See also under *C. torrentium*.

C. territans Walker
Synonym: *C. apicalis* Adams. Larva not found in Finland, but adult recorded once in South Finland. Holartic.

C. torrentium Martini
In South and Central Finland. Palaearctic. The key charasteristics differentiating the larvae of *C. torrentium* from *C. pipiens* overlap somewhat; hence single specimens cannot be identified with certainty.

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Pirkka Utrio[1]
Department of Virology
University of Helsinki
Haartmaninkatu 3,
SF-00290 Helsinki 29

[1] Present adress:
Department of Zoology
University of Helsinki
Pohjois-Rautatiekatu 13
SF-00100 Helsinki 10

SELOSTUS

Suomen hyttystoukkien (Diptera, Culicidae) tutkimuskaava

PIRKKA UTRIO

Helsingin yliopisto

Suomen hyttysten IV-asteen toukille esitetään sekä suvut että lajit käsittävä tutkimuskaava. Useimmat lajit on kuvattu piirroskuvina kotimaisten yksilöiden perusteella. Tutkimuskaava sisältää 36 lajia, joista *Aedes punctodes* Dyar ja *Culiseta silvestris ochroptera* (Peus) ilmoitetaan ensi kerran Suomessa tavatuiksi.

ANNALES AGRICULTURAE FENNIAE, VOL. 15: 137—144 (1976)

Seria ANIMALIA NOCENTIA N. 89 — Sarja TUHOELÄIMET n:o 89

CHEMICAL CONTROL OF SUGAR-BEET PESTS IN FINLAND: EFFICIENCY AND ECONOMIC RETURN

ANNA-LIISA VARIS and JORMA RAUTAPÄÄ

VARIS, A.-L. & RAUTAPÄÄ, J. 1976. **Chemical control of sugar-beet pests in Finland: efficiency and economic return.** Ann. Agric. Fenn. 15: 137—144. (Univ. of Helsinki, Dept. Agric. For. Zool. SF-00710 Helsinki 71, Finland).

Between 1958 and 1973 field experiments were performed at 14 localities in southern Finland to study the control of the sugar-beet pests, *Lygus rugulipennis* Popp., *Chaetocnema concinna* Marsh. and *Pegomya betae* Curt.

When *L. rugulipennis* and *C. concinna* were controlled by applying dimethoate, formothion and parathion sprays, parathion dust and wettable powder, without any prior knowledge of damage likely to be caused by these species, the greatest increase in root yield per hectare was obtained with dimethoate (1.7 tons or 4.3 %). In terms of money, the value of the total yield (root + top yield), after insecticide costs had been deducted, was 225 Fmk (1 Fmk = 0.25 US $) per hectare when dimethoate was used, or about 9 % of the average gross margin for sugar-beet in 1972.

In years when fairly heavy damage was expected and *P. betae* was controlled by dimethoate spray, granulated thionazin and phorate, and trichlorphon wettable powder, the greatest increase in root yield per hectare (3.0 tons or 7.7 %) was obtained with dimethoate. The largest increase in the cash value of the total yield per hectare was also obtained with dimethoate (414 Fmk or 17 % of the average gross margin). When all three species were controlled without knowing the expected damage, the following insecticides were used: granulated aldicarb, disulfoton and parathion, dimethoate spray, parathion spray or dust followed later by trichlorphon wp treatment. Dimethoate spray and phorate increased root yield most (1.9 tons or 7.1 and 7.6 % respectively). In terms of money the largest increase in total yield after deducting insecticide costs was obtained with dimethoate (283 Fmk or 11 % of average gross margin per hectare).

Index words: sugar-beet pests, chemical control, efficiency, economic return.

INTRODUCTION

The pests most harmful to sugar-beet in Finland are *Lygus rugulipennis* Popp. (*Het.*, *Miridae*), *Chaetocnema concinna* Marsh. (*Col.*, *Halticinae*) and *Pegomya betae* Curt. (*Dipt.*, *Anthomyiidae*); all these species are common throughout the country. The occurrence of these species in different years and damage caused by them (according to inquiries sent out to advisors) have been reviewed in periodical surveys of pests attacking cultivated crops in Finland (VAPPULA 1965, MARKKULA 1966—1973 a, 1974). The biology and chemical control of *L. rugulipennis* and the damage done by the bug has been studied by VARIS (1959 a, 1971, 1972), as has the control of *P. betae* (VARIS 1959 b).

L. rugulipennis injures the sugar-beet seedlings in late May and early June, when they have just emerged. A short feed of a few minutes duration can damage or destroy the growing point of a seedling and cause distorted growth and multiple crowns. Yield from damaged plants is considerably reduced and the sugar content is below normal (VARIS 1972).

Although capable of injuring young seedlings quite seriously in May and early June, *C. concinna* is generally considered less serious than *L. rugulipennis*.

There are two generations of *P. betae* per year. The first usually lays its eggs about mid-June and the larvae attack sugar-beet leaves in the second half of June. Larvae of the second generation appear in August. In Finland, control measures are recommended when at least twenty eggs are discovered on a plant consisting of an average of five rough leaves (VARIS 1966).

Control measures are usually taken against *L. rugulipennis* and *C. concinna* in late May, or when about 50 % of the seedlings have emerged. Plants are usually treated with sprays or wettable powders, either once or twice with an interval of 5—10 days. If the eggs of the first generation of *P. betae* appear in sufficiently large numbers, treatment against the larvae may be required around mid-June. It is not customary, however, to control larvae of the second generation.

From the late 1950s until the end of the '60s, *L. rugulipennis* and *C. concinna* were most commonly controlled by spraying with parathion or by dusting with a mixture of parathion and DDT. Dimethoate came on the market in the early '60s and has been one of the most important pesticides used on sugar-beet in the present decade. The use of DDT in agriculture was discontinued in the autumn of 1971.

Granulated preparations have not been used widely in Finland, and seed treatment with lindane has been confined to a rather limited area in the western part of the country.

Official tests on insecticides, based on the compulsory registration and testing of pesticides (see MARKKULA 1973 b), are carried out by the Institute of Pest Investigation of the Agricultural Research Centre. Several insecticides have been tested in field trials located at the Centres' experimental stations in various parts of Finland and also in cooperation with the Research Centre for Sugar-Beet Cultivation on the experimental farms of four (until 1970, five) regional beet-sugar factories. The aim of the present report is to summarize the results of the long-term experiments and to discuss the economic return obtained controlling *L. rugulipennis*, *C. concinna* and *P. betae* with various pesticides.

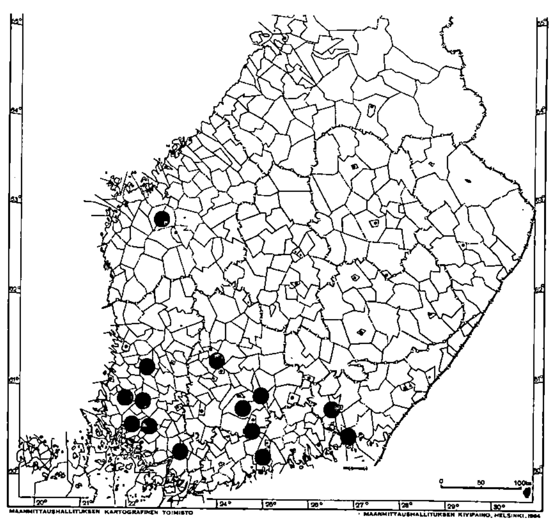

Fig. 1. Experiments were located at the following places in southern Finland: Kotka, Anjala, Tikkurila, Hauho, Hyvinkää, Salo, Turenki, Peipohja, Pälkäne, Ylistaro, Säkylä, Köyliö, Kaarina ja Mietoinen.

MATERIAL

Variations in injury in the experiments

To show the extent of injury by three species in various years, injury data from all untreated plots in the 1958—1973 experiments were compiled. The total number of experiments were as follows: *L. rugulipennis* 128, *C. concinna* 98, and *P. betae* 52.

Economic return of control

For this purpose experiments were selected in which either *L. rugulipennis* and *C. concinna*, *P. betae* alone, or all three species were controlled and in which similar methods were applied. Each experiment consisted of several treatments using different preparation or application rates. Those which proved to be detrimental to plants were deleted. Results comparings seed dressing and spraying of seedlings are given elsewhere (VARIS 1975).

The experiments were carried out at 14 localities in southern Finland (Fig. 1).

METHODS

Normal, generally approved cultivation techniques were applied. The fertilization and tillage methods considered most beneficial to growth were followed. The seeds were sown by dense drilling in 1958—1968 and widely spaced (with monogerm seed) after that. Thinning was usually performed in the middle of June.

Usual plot size was 20—60 sq.m. and three to six replicates were made. An experiment consisted of untreated plots and six to eight plots treated with different preparations or application rates. In many experiments one of the treatments was parathion or dimethoate spray.

To control *L. rugulipennis* and *C. concinna*, the treatments were applied at about 50 % seedling emergence. In most experiments spraying or dusting was repeated some seven or ten days later. If first-generation larvae of *P. betae* were to be controlled as well, the stands were sprayed once more, in the middle or towards the end of June. In some experiments the first generation larvae of *P. betae* only were controlled and no treatments against *L. rugulipennis* and *C. concinna* were applied.

The granulated pesticides were spread onto the seeded drills or rows of seedlings before or during emergence in experiments, where all three species were to be controlled, and in the middle of June when only *P. betae* was controlled. In some of the later-years all the plots, including those which had been treated with insecticides, were sprayed with phenmedipham.

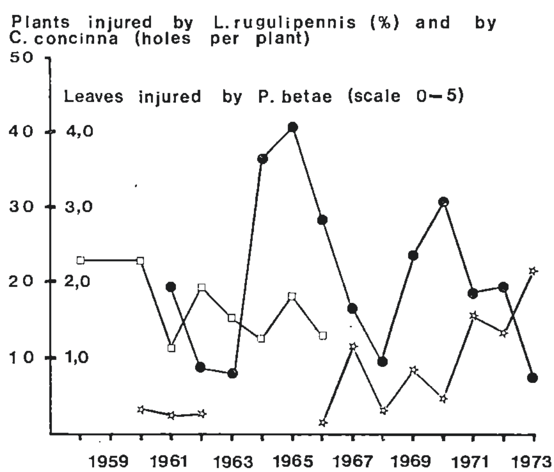

Fig. 2. The average injury caused by *L. rugulipennis* (dots), *C. concinna* (stars) and *P. betae* larvae (squares) in untreated plots of experiments in the years 1958—1973.

Inspection of experiments

In mid-June, at thinning time at the latest, 30—50 young plants were taken up from each plot for investigation. Plants on which the growing points had been destroyed were regarded as being damaged by *L. rugulipennis* (see VARIS 1972). Feeding holes made by *C. concinna* were counted. Damage by the *P. betae* larvae was assessed in 1958—1966 by inspecting all the leaves of 25 plants per plot in late June or early July and estimating the damage on a scale of 0—5 (0 = completely healthy, 5 = completely destroyed).

In connection with thinning the most seriously damaged seedlings were removed. When the seeds had been sown widely spaced, this was not always possible. The yield was harvested at the normal time. In most experiments both root and top yields were recorded.

Analyses of results

To show the annual variation in pest damage, observations on each year's untreated plots were pooled. To compare economic returns of the different control methods, the material was divided into three separate groups. The first one (Fig. 3) consisted of experiments in

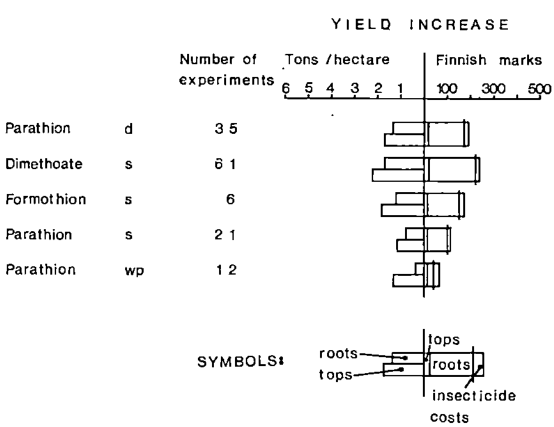

Fig. 3. Effect of chemical control of *L. rugulipennis* and *C. concinna* on the root and top yield, and the cash value of yield increase in Finnish marks.

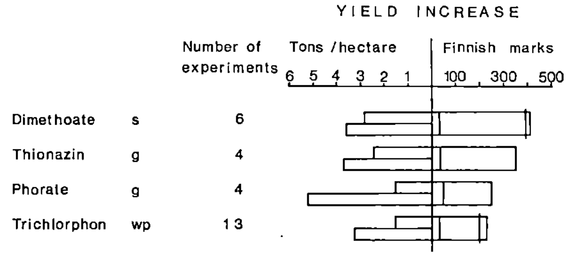

Fig. 4. Effect of chemical control of *P. betae* on yield, and cash value of yield increase. Symbols are presented in Fig. 3.

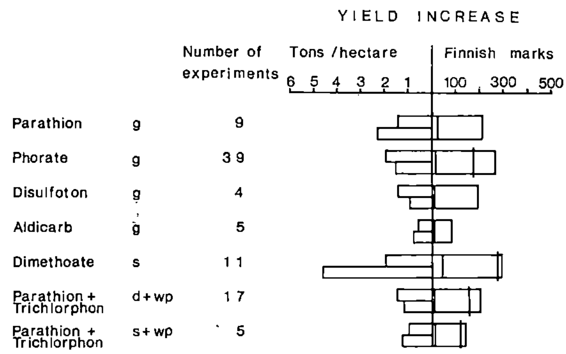

Fig. 5. Effect of chemical control of *L. rugulipennis*, *C. concinna* and *P. betae* on yield, and cash value of yield increase. Symbols are presented in Fig. 3.

which *L. rugulipennis* and *C. concinna* were controlled while *P. betae* was not. The second group (Fig. 4), included tests in which *P. betae* alone was controlled. The third group (Fig. 5) comprised the experiments in which all three species were controlled either by granulated preparations or by spraying or dusting 3—5 times. In these tests the effect of granulated preparations was often compared whith the effect of sprays and dusts, and the future incidence of damage was not known beforehand. The results of these experiments were used to compare sprayings with parathion and dimethoate.

The cash value of a change in root yield as a results of insecticide treatment was calculated on the basis of the price for beets paid to farmers in 1972, 132 Fmk/ton. Price differences due to variations in sugar content were not taken into consideration.

The value of the top yield was calculated as follows. According to 1972 fertilizer prices the value of tops used for green manure was estimated to be about 6 Fmk/ton. When used for fodder, one ton of sugar-beet tops gives about 450 kg of silage. About 7,5 kg of beet tops, used as silage, corresponds to one Scandinavian feed unit (ANON. 1969), and the price of one feed unit in 1972 was about 0.40 Fmk. The top yield of one ton thus converts to a value of about 24 Fmk. With the ensiling costs estimated at about half the price of tops used for fodder, there remains a value for the yield of 12 Fmk. It is assumed that half of the crop of sugar-beet tops is used for fodder and half for manure. The mean, 9 Fmk/ton, has therefore been used in this study as the basis for top yield calculations.

Prices for pesticides were obtained from commercial catalogues for 1972 and were those quoted for the largest retail package sold. Prices for pesticides no longer on sale in 1972 were estimated by adjusting the last known retail price according to subsequent general rises in the prices of pesticides. Granulated parathion and thionazin have never had a retail price in Finland.

RESULTS

Variations in injury in the experiments

Injury caused by *L. rugulipennis* was most severe in the years 1964—1966, 1969, and 1970 (Fig. 2). In 1965 an average of 41 % of the seedlings were damaged, in 1970 33 %. Least damage was observed in 1963 (8 %) and 1968 (6 %).

The average number of *C. concinna* feeding holes per plant was under 10 in the late 1960's but increased considerably in the 70's. The worst damage was observed in 1973 (21.5 holes/plant, Fig. 2).

Injury by *P. betae* larvae was quite serious in the early '60s with an average score of nearly 2 in the 0—5 scale. In 1966 there was still considerable injury by larvae (mean 1.0), but after 1966 it was slight, even though the damage was not recorded in detail.

Changes in the yield

When *L. rugulipennis* and *C. concinna* were controlled, the root yield was increased most by dimethoate sprays (1.7 ± 1.3 tons/hectare; 4.3 %, Fig. 3) and least by parathion wp (0.4 ± 1.6 tons). The top yield was increased most by dimethoate, too (2.3 ± 2.1 tons, 6.1 %), and least by parathion spray (1.1 ± 1.0 tons).

In general, control of *P. betae* larvae improved the yield more than the treatments against *L. rugulipennis* and *C. concinna* did (Fig. 4). The increase in root yield varied from 2.9 ± 3.6 tons per hectare (= 7.7 %) with dimethoate to 1.5 ± 1.2 tons with trichlorphon wp. The largest change in top yield was obtained with granulated phorate (5.3 ± 4.2 tons, 12.2 %) and even the smallest increase was relatively large, 3.3 ± 3.4 tons/hectare, with trichlorphon wp. It should be mentioned that steps were taken to control *P. betae* only when damage was anticipated on the basis of egg counts, while at least one treatment was applied in any case to counteract *L. rugulipennis* and *C. concinna* at the cotyledon stage in the tests presented in Figs. 3 and 5.

When all three species were controlled (Fig. 5), the largest root yield increase was achieved with dimethoate (2.0 ± 1.7 tons/hectare, 7.1 %) and the least with aldicarb (0.6 ± 0.4 tons). The difference between dimethoate sprays and granulated phorate was negligible. Dimethoate sprays caused the largest increase in top yield (4.7 ± 3.5 tons, 16.4 %) and aldicarb the least (0.8 ± 0.7 tons).

Experiments, totalling18, in which dimethoate and parathion sprays were compared, did not reveal any significant differences. Preliminary analyses denoted that the increases in root yield were not correlated with the damage done by *L. rugulipennis* and *C. concinna* but that there might be a significant correlation between the yield increase and damage caused by *P. betae* larvae. It is planned to publish the detailed analysis later.

Economic return on control

When *L. rugulipennis* and *C. concinna* were controlled, the largest increase using in the combined value of root and top yield, 240 Fmk/hectare, was obtained using dimethoate spray (Fig. 3). The growth in the value of the root yield caused by dimethoate was 220 Fmk and that of the top yield 20 Fmk. The retail price of pesticide used in these experiments was about 15 Fmk and thus the net gain using dimethoate spraying was about 225 Fmk excluding the labour costs involved in treatment. The smallest average increase in the value of root and top yield was obtained with parathion wp, 63 Fmk. The cost of pesticide was 21 Fmk and the net gain thus 42 Fmk/hectare.

Control of *P. betae* with dimethoate (Fig. 4) improved the total value of the yield by 426 Fmk, 33 Fmk of which represented the increase in the tops. The price of dimethoate used in tests was 12 Fmk and the net gain 414 Fmk per hectare. Trichlorphon wp increased the yield least, by 232 Fmk, and since the insecticide cost 22 Fmk, the net gain was 210 Fmk. Thionazin and phorate improved the yield value by 364 Fmk and 258 Fmk correspondingly. The price of phorate is estimated to be about 100 Fmk per hectare, even though it has not been sold for several years. Thionazin has never had a retail price in this country.

When all three species were controlled, dimethoate increased the yield most (by an average 301 Fmk/hectare) and aldicarb least (86 Fmk/hectare). The other granulated preparations improved the value of the yield as follows: phorate 271 Fmk, parathion 212 Fmk and disulfoton 197 Fmk per hectare. Combined use of parathion dust and trichlorphone wp increased the yield value by 209 Fmk and that of parathion spray and trichlorphone wp by 145 Fmk/hectare.

DISCUSSION

L. rugulipennis is a species relatively difficult to control. Even in a short feed the bugs may damage a plant seriously and one single bug is capable of injuring a large number of plants in a short time (see VARIS 1972). Any pesticide used against the *Lygus* bugs would be required to retain its protective effect over a period of some weeks. *C. concinna* and *P. betae* are not such a problem as *L. rugulipennis* in this respect: the damage they do, usually develops slowly and more time is left to the farmer to make his decision on the necessity of chemical control. In general, the best result in these experiments was achieved with dimethoate even though the difference between dimethoate and other pesticides, such as parathion dust or granulated parathion and phorate, was not great.

The relatively large variation in yield increases achieved by certain pesticides in different experiment, which is reflected in large standard errors in the mean (see Results section), suggests that the test results are heterogenous, due, apparently, to the variations in damage in different years and places, and also because in many cases the control measures were not as successful as they might have been. For example, the mean increase in root yield with dimethoate shown in Fig. 3, when *L. rugulipennis* and *C. concinna* were controlled, was 1.7 tons and the standard error ± 1.3 tons. The greatest increase in root yield with dimethoate, when *L. rugulipennis* and *C. concinna* were controlled, was in one particular experiment 4.7 tons/hectare and the least was −2.0 tons.

At present no control recommendations based on prognoses are available for *L. rugulipennis* and *C. concinna* and the control measures usually have to be taken without any prior knowledge of what damage may be expected. Weather conditions can change rather unexpectably and cause changes in the behaviour of seedling pests. On the other hand, the need for chemical control of *P. betae* larvae can be calculated by simple egg counts and there is usually enough time to follow the development of injury. Preliminary calculations based on the material in this study showed no significant correlation between the degree of injury caused by *L. rugulipennis* or *C. concinna* and the effects of chemical control on yield. On the other hand, injury caused by *P. betae* larvae seemed to be correlated with the yield increases. Evidently, in practice, numbers of insecticide treatmens are applied nowadays without any significant effect on yield, but average yield increases after the usual insecticide applications are, however, large enough to make the control measures worthwhile.

The costs of insecticides used in these experiments proved to be relatively small compared with average increases in yield. With dimethoate the average cost of the insecticide in all experiments was 3—6 % of the cash value of yield increases. Labour costs were not calculated, but they are generally estimated at about 15—20 Fmk/hectare for one treatment. With the insecticides giving the best results the gain still remains significant even after labour and insecticide costs have been deducted from the cash value of yield increase. The yield increase caused by some insecticides was, however, relatively small and costs of treatments higher than with dimethoate, so that the financial gain was minute.

The average gross margin for sugar-beet in 1972 was calculated to be about 2.500 Fmk/hectare before deducting the costs of field work (ANON. 1972). In experiments with *L. rugulipennis* and *C. concinna*, the highest cash value of yield increase after deducting the insecticide costs was about 9 % of the gross margin. In experiments with *P. betae* the corresponding highest percentage figure was about 17 % with dimethoate spray, and in experiments with all the three species about 11 %.

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Anna-Liisa Varis
University of Helsinki
Department of Agricultural and Forest Zoology
SF-00710 Helsinki 71, Finland

Jorma Rautapää
Agricultural Research Centre
Institute of Pest Investigation
SF-01300 Vantaa, Finland

SELOSTUS

Sokerijuurikkaan tuholaistorjunnan kannattavuus

Anna-Liisa Varis — Helsingin yliopisto

Jorma Rautapää — Maatalouden tutkimuskeskus

Vuosina 1958—1973 neljällätoista paikkakunnalla Etelä- ja Keski-Suomessa tehdyissä sokerijuurikkaan tuholaisten torjuntakokeissa vioittivat peltoluteet taimia eniten 1964—1966, 1969 sekä 1970. Vuonna 1965 oli keskimäärin 41 % kaikista taimista, joita ei käsitelty torjunta-aineilla, vioittunut. Juurikaskirppoja oli 1960-luvulla yleensä vähän, mutta niiden aiheuttamat vioitukset lisääntyivät 1970-luvun alussa. Juurikaskärpästä sitävastoin oli runsaasti 1960-luvun puoliväliin saakka, mutta vuoden 1966 jälkeen on sen torjunta ollut tarpeen vain harvoin.

Kasvit käsiteltiin torjunta-aineilla peltoluteita ja samalla kirppoja vastaan silloin kun puolet niistä oli taimistunut. Kokeissa, joissa torjuttiin yksinomaan juurikaskärpästä, taimet käsiteltiin silloin kun puolet toukista oli kuoriutunut ja munien määrän perusteella voitiin odottaa kohtalaisen runsasta vioitusta. Kokeissa, joissa torjuttiin kaikkia kolmea lajia, oli usein tarkoituksena verrata rakeistettujen valmisteiden tehoa pölytteiden ja ruiskutteiden tehoon eikä tuholaisten ja niiden aiheuttamien vioitusten runsautta voitu tietää etukäteen.

Peltoluteen ja juurikaskirpan torjuntakokeissa lisäsi dimetoaattiruiskute sekä juurisatoa (keskimäärin 1.7 tonnia hehtaaria kohden; 4.3 %) että naattisatoa eniten (2.3 tn; 6.1 %). Vuoden 1972 hintatason mukaan oli dimetoaatin aikaansaama juuri- ja naattisadon lisäyksen raha-arvo keskimäärin 240:— hehtaaria kohden. Kokeissa käytetyn dimetoaatin ainekustannus oli 15:—/ha, joten torjunnan antama lisätuotto ilman ruiskutuksen työkustannuksia oli 225:— hehtaaria kohden.

Torjuttaessa juurikaskärpästä lisäsi dimetoaatti juurisatoa eniten (keskimäärin 3.0 tn/ha; 7.7 %). Suurimman naattisadon lisäyksen aiheutti rakeistettu foraatti (5.3 tn/ha; 12.2 %). Dimetoaatin antaman sadonlisäyksen raha-arvo oli keskimäärin 426:— hehtaaria kohden ja tuotto, kun ainekustannukset vähennettiin tästä, 414:— hehtaaria kohden.

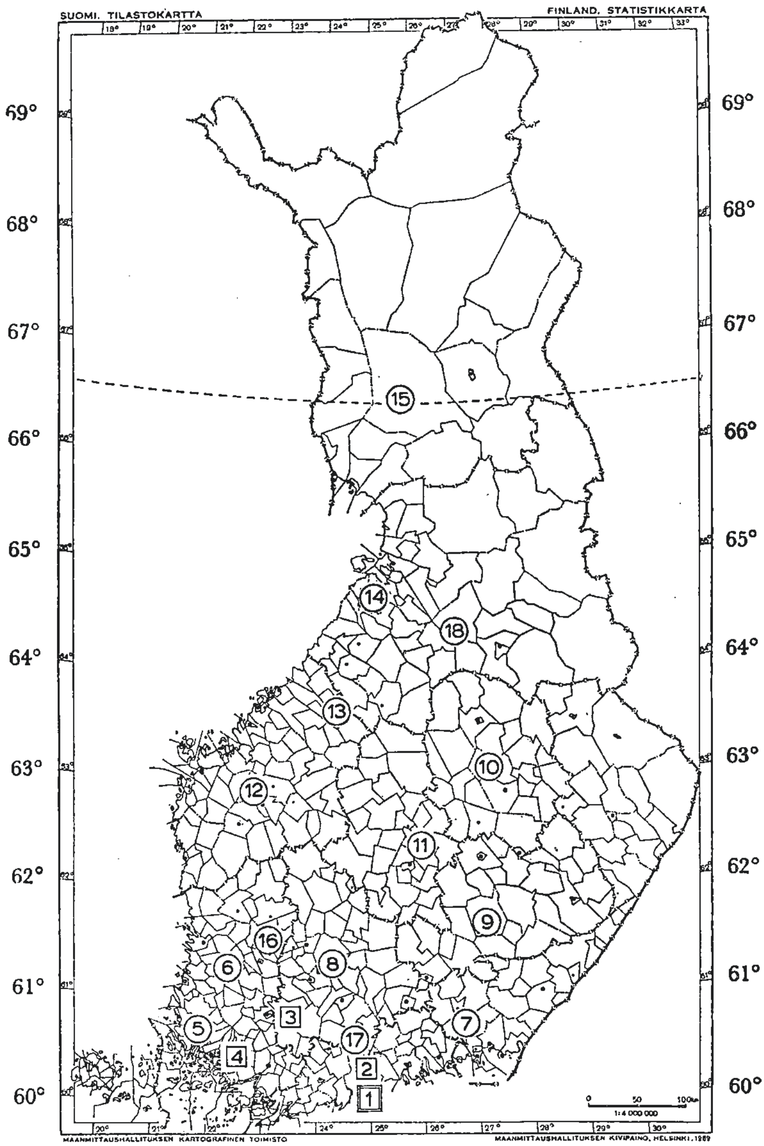
Kun torjuttiin peltoluteita, juurikaskirppoja ja juurikaskärpästä, lisäsivät dimetoaatti ja foraatti juurisatoa jokseenkin saman verran (1.9 tn/ha; 7.1 ja 7.6 %). Dimetoaatti lisäsi naattisatoa eniten (4.7 tn/ha; 16.4 %). Kun torjunta-aineen kustannus vähennettiin juuri- ja naattisadon lisäyksen arvosta, oli dimetoaatin aikaansaaman sadonlisäyksen rahallinen arvo suurin, 283:—/ha.

Vuoden 1972 vähittäismyyntihintojen perusteella oli ainekustannus ruiskutteilla, ruiskutejauheilla ja pölytteillä 12—45:— hehtaaria kohden eli 3—30 % eri aineilla saadun sadonlisän raha-arvosta.

Kun yleensä parhaan tuloksen antaneen torjunta-aineen, dimetoaatin, ainekustannukset vähennettiin sadonlisäyksen raha-arvosta, oli lisäsadon arvo luteita ja kirppoja torjuttaessa keskimäärin noin 9 % sokerijuurikkaan katetuotosta 1972, juurikaskärpästä torjuttaessa 17 % ja kaikkia kolmea lajia torjuttaessa 11 %.

Torjunnan työkustannuksia ei erikseen selvitetty, mutta vuonna 1972 yhden ruiskutuksen arvioitiin yleensä maksavan 15—20 mk/ha.

Vuoden 1972 jälkeen on sokerijuurikkaan perushinta kohonnut huomattavasti kun taas torjunta-aineiden hinnat ovat pysyneet lähes samoina. Tuholaisten torjunta on sen vuoksi tullut kannattavammaksi.



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