med.no. 77

C 1643

Magazijn

's-Gravenhage 21/10 '65

# ITBON

1940—1965

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Itbon 1940—1965

# ITBON

## 1940—1965

INSTITUUT VOOR TOEGEPAST BIOLOGISCH ONDERZOEK IN DE NATUUR
(INSTITUTE FOR BIOLOGICAL FIELD RESEARCH)

KEMPERBERGERWEG 11, ARNHEM, NETHERLANDS

MEDEDELING NR. 77/1965

## INHOUD



## CONTENTS

# VOORWOORD

Ons Instituut beschouwt de viering van zijn 25-jarig bestaan niet als een formaliteit. Integendeel als een gelegenheid voor bestuur, directie en personeel om het verleden aan hun geestesoog voorbij te laten gaan. Zij zullen terugdenken aan medewerkers die dit jubileum niet meer hebben mogen meemaken en aan de betrekkingen tot hen waarmee zij vaak lange jaren hebben samengewerkt. Dit doende realiseren zij zich hoe belangrijk het persoonlijke element is in ons dagelijks werk. Ook zullen zij de ontwikkeling van het werk in de voorbije periode in beschouwing nemen, zij zullen zich ondervonden moeilijkheden in herinnering brengen, nagaan wat is bereikt en welke uitzichten op de toekomst zich openen. Aldus kan het jubileum ons onderzoek stimuleren, omdat het Instituut zijn weg bewuster vervolgt.

De groei van een uiterst kleine gemeenschap in een miniatuur-laboratorium te Hoenderloo tot een middengroot instituut heeft met zich meegebracht dat de contacten zich zeer aanzienlijk hebben uitgebreid. Dit heeft het voordeel van een meer en beter verankerd raken in de maatschappij waarvoor wij tenslotte werken. Het brengt echter ook een gevaar met zich mee, namelijk dat het onderzoek wordt geremd doordat de contacten teveel tijd van de onderzoekers gaan vergen. Over dit onderwerp houdt tijdens het jubileum de voorzitter van ons bestuur een rede geheten 'Parafrase over ontmoetingen'.

Het bestuur heeft gemeend er goed aan te doen een z.g. 'Mededeling Itbon' geheel te wijden aan deze eerste vijfentwintig jaar. Behalve de genoemde rede bestaat het boek uit drie delen, waarvan de eerste twee de ontwikkeling van instituut en werk behandelen en het laatste een complete opsomming van onze publikaties geeft. Het tweede deel, 'Research', is mede bedoeld voor de buitenlandse collega's en daarom in het Engels gesteld. Uit de verschillende hoofdstukken blijkt dat ons onderzoek een aanzienlijke groei heeft ondergaan en dat visie op de toekomst steeds als een onmisbaarheid is begrepen. Bovendien komt tot uiting, dat ook in het fundamentele deel van het werk het praktische belang aanhoudend op de voorgrond heeft gestaan. Reeds kon veel van hetgeen het onderzoek ons leerde ter beschikking van de praktijk worden gesteld.

Bezinning op dit tijdperk geeft ons de overtuiging dat voor het Instituut een goede toekomst is weggelegd.

## PARAFRASE OVER ONTMOETINGEN

*Rede ter gelegenheid van het vijfentwintig-jarig bestaan van het Instituut voor Toegepast Biologisch Onderzoek in de Natuur te Arnhem*

**Dr. P. M. L. Tammes**
*Voorzitter van het bestuur*

In het vooruitzicht van de bijeenkomst die thans een feit is, heb ik mij gerealiseerd dat veel van ons denken en doen met ontmoetingen samenhangt.

Met dit in gedachten wilde ik wat op het begrip 'ontmoeting' gaan parafraseren. Enkele vormen zoals ik die heb leren kennen bij mijn werk als bioloog zullen daarbij in bespreking komen, en mijn verkenning zal ik afsluiten met een nabeschouwing over het contact, dus de ontmoeting, van onderzoekers onderling en met de praktijk.

*

Ter inleiding een voorbeeld uit de wereld van de dode materie. Ongeveer een eeuw geleden hebben twee Noren een wet geformuleerd, die naar hen is genoemd de Wet van Guldberg en Waage. Deze wet zegt o.a. dat de reactiesnelheid van twee stoffen evenredig is met het produkt van hun concentraties, wel te verstaan onder gelijkblijvende overige omstandigheden. Velen hebben op de middelbare school gepuzzeld met sommen hierover en zich wellicht afgevraagd waarom men met het produkt van de concentraties te maken heeft en niet met de som daarvan.

De moleculen van twee onderling reagerende stoffen ontmoeten elkaar en bij die ontmoeting kan reactie optreden. Het aantal ontmoetingen is daarbij maatstaf voor de snelheid van de reactie. Wordt één van de componenten verdubbeld, dan zal men tweemaal zoveel ontmoetingen mogen verwachten; doet men ditzelfde nu ook met de andere component, dan wordt het aantal ontmoetingen $2 \times 2$ zo hoog en de reactiesnelheid neemt met een factor 4 toe, dus met het produkt.

*

Ook bij levende organismen zijn er omstandigheden waarbij het aantal ontmoetingen een rol speelt. Bij granen kent men de z.g. roest. De schimmel die deze ziekte veroorzaakt vormt sporen, die door de wind worden verspreid.

Deze sporen ontkiemen op de bladeren van graan, er ontstaan woekeringen en tenslotte weer sporen die worden verspreid. Dit gaat zo enige malen achter elkaar in één seizoen. De totale vermeerdering van een dergelijke graanroest bij bijvoorbeeld gunstige weersomstandigheden hangt enerzijds af van het aantal sporen dat per oppervlak neervalt, dus van de dichtheid van de sporenpopulatie, anderzijds van het aantal graanplanten dat per oppervlak aanwezig is. Plant men bijvoorbeeld een gelijk mengsel van een vatbaar en een resistent graanras, dan vermeerdert de roest zich alleen op het vatbare ras en bij de volgende generaties krijgt men vermeerderingen die respectievelijk 1/2, 1/4, 1/8, enz. bedragen van een perceel dat geheel met een vatbaar ras is beplant. De vermeerderingsfactor is namelijk slechts de helft en de toename loopt dus op als bij een samengestelde interest waarbij de rentevoet is gehalveerd. Dit geldt echter alleen zolang het aantal infecties klein is ten opzichte van het aantal planten en uiteraard slechts voor grote percelen of arealen. Voor de oogstreductie van rassen in een gemengde aanplant van lijnen met een ongelijke resistentie voor roestfysio's kan het echter van belang zijn, en het maken van mengrassen is daarom wel overwogen (JENSEN 1952, BORLAUG 1958, ZADOKS 1961). Men kan hier spreken van een z.g. dichtheidsafhankelijke factor, dat is een factor die afhankelijk is van de dichtheid van de vatbare populatie.

*

Bij beweeglijke dieren zijn wij geneigd te denken dat het aantal ontmoetingen tussen de seksen wel groot genoeg zal zijn om de voortplanting niet te belemmeren. In het geval van een zeer lage dichtheid is die belemmering er echter wel degelijk wanneer de afstanden zo groot worden dat zij buiten zintuigelijke waarneming vallen. Onder dergelijke omstandigheden van onderbevolking mag men verwachten dat de kans dat mannetjes en wijfjes elkaar ontmoeten en dus de voortplanting stijgt, toeneemt met het aantal aanwezige mannetjes. Dit is grafisch voorgesteld in fig. 1 naar een model van KLOMP, VAN MONTFORT en TAMMES, 1964.

Zijn de seksen in aantal gelijk, dan zal numerieke verdubbeling bij lage dichtheid zelfs een viervoudig aantal ontmoetingen kunnen geven, een vermeerdering dus volgens een factor evenredig met het produkt van de dichtheid der twee seksen.

Dergelijke gegevens zijn echter zeer moeilijk te verkrijgen. Populatiestudies, op zichzelf al lastig, zijn bij uiterst geringe dichtheden nagenoeg onuitvoerbaar, zodat beschouwingen meestal neerkomen op indirecte aanwijzingen of berekeningen aan theoretische modellen.

Bij ongeslachtelijke voortplanting heeft men niet te doen met ontmoetingskansen, en de beperkingen daarvan bij geringe dichtheden maken wellicht

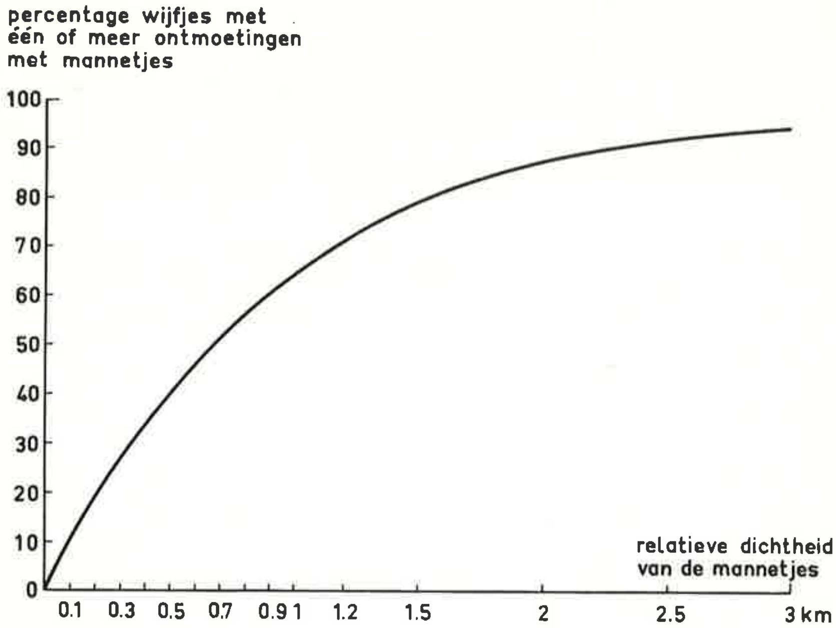



Fig. 1. De factor *k* is een maat voor de activiteit van de mannetjes; *m* = aantal mannetjes. Bij een relatieve dichtheid van 1 km is in het model gesteld dat per 100 wijfjes 100 ontmoetingen plaatshebben. Op de verticale as het % wijfjes met *één of meer* ontmoetingen.

dat een ongeslachtelijke voortplanting in dergelijke gevallen zo goed van pas kon komen.

Bij de bestrijding van parasitaire organismen gaan wij vaak uit van de aanwezigheid of nadering van een schadelijk niveau van de parasieten op gewassen, alvorens deze curatief te bestrijden. Een tweede mogelijkheid is de preventieve methode, waarbij dus gezorgd wordt dat het schadelijk organisme geen ontwikkelingskansen heeft. Een derde mogelijkheid, ook preventief, is het aangrijpen van de schadelijke organismen op het tijdstip dat zij het geringst in aantal zijn, en dan dit aantal zover terug te dringen dat bij volgende generaties geen kans meer bestaat een schadelijk niveau te bereiken. Een voorbeeld is de vroege voorjaarsbespuiting op appel tegen de bloedluis, die dan op het laagste niveau staat, met het doel zo schoon mogelijk het voorjaar in te gaan.

In het noorden van Engeland komt op schapenweiden een teek voor, waarvan de levensloop door Milne bekend is geworden. De jonge teken blijven het grootste deel van het jaar in de grasmat. In een bepaalde periode echter klimmen ze in een grashalm omhoog. Als, gedurende de week dat zij het daar kunnen uithouden, een schaap langs de halm schuurt, zijn zij gered.

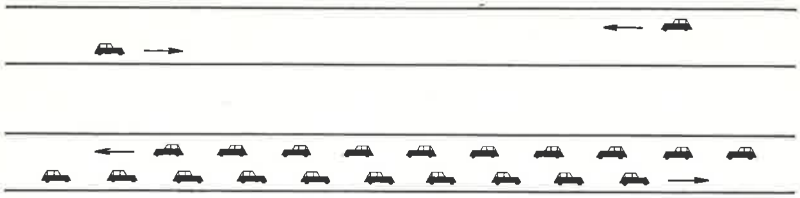
Wanneer bovendien mannetjesteken en wijfjesteken op één schaap terecht komen, dan leidt dit tot een behoorlijke nakomelingschap. Vele jonge teken missen echter de kans van hun leven om een schaap te treffen en gaan te gronde. Die kans om op een schaap terecht te komen neemt evenredig toe of af met het aantal schapen dat per oppervlak aanwezig is. Er kan zelfs een toestand voorkomen dat er zo weinig schapen zijn dat de aanwas van de teken de sterfte niet meer dekt, en de tekenpopulatie in het veld zal in aantal teruglopen. Is dit laatste het geval, dan neemt de kans dat zowel mannetjesteken als wijfjesteken op een schaap terecht komen snel af. Wat ziet men nu in de praktijk? De teken komen reeds sedert eeuwen in het noorden van Engeland voor, maar lang niet op alle schapenweiden, hoewel deze vaak als enige grens een afrastering hebben. De ervaring leert bovendien dat een tekenpopulatie zeer langzaam op gang komt en dit wordt door het voorgaande wel begrijpelijk.

*

Heeft men dus bij zeer geringe dichtheden te doen met de gevolgen van de numerieke beperktheid der ontmoetingen, bij grote dichtheden stuit men uiteraard op het tegendeel.

Bijzonder pijnlijk wordt dit aspect als wij het gaan toepassen op de huidige verkeersintensiteit. Beperken wij ons hierbij tot de aanrijdingen die op autowegen voorvallen bij tegenligging of inhaling. Zulke gebeurtenissen kunnen wij inderdaad zien in verband met het ontmoetingsthema. Men kan stellen dat per x miljoen gereden kilometers een aanrijding plaatsheeft. M.i. met meer reden kan men echter stellen dat er een aanrijding voorvalt per y miljoen ontmoetingen, hetzij tegenliggingen of inhalingen. Het eerste gegeven bevat geen dichtheidsafhankelijke factor en wordt dus verondersteld onafhankelijk te zijn van de drukte op de weg. De tweede veronderstelling bevat deze dichtheidsafhankelijke factor wel. Als men hier nader op ingaat en het aantal aanrijdingen, onder overigens gelijke omstandigheden, evenredig stelt met het aantal tegenliggingen of inhalingen, dan betekent dit dat voor de individuele weggebruiker de kans op een aanrijding evenredig toeneemt met de verkeersintensiteit. Voor het totale verkeer stijgt die kans met het kwadraat van de intensiteit, terwijl daarentegen de hoeveelheid verbruikte benzine slechts rechtevenredig toeneemt. Dus bijvoorbeeld, bij 10-maal zoveel auto's op de weg in beide richtingen 10-maal zoveel benzine en ook 10-maal zoveel kans op een aanrijding voor de individuele weggebruiker, maar 100-maal zoveel tegenliggingen en inhalingen en ook 100-maal zoveel kans op een aanrijding in het betrokken verkeersgebied. Fig. 2 verduidelijkt dit:

twee auto's: één ontmoeting



twintig auto's: honderd ontmoetingen

Natuurlijk zijn hier tegenwerkende factoren. Als het drukker wordt op de weg, gaat men langzamer en voorzichtiger rijden. Dit langzamer rijden brengt echter ook weer meer auto's op een weggedeelte en daardoor uiteindelijk weer meer ontmoetingen, dus tegenliggingen of inhalingen. Ergens ligt hier dus een grens. Verder zijn de tegenwerkende factoren ook wel twijfelachtig als men ziet hoe er op spitsuren wordt gereden.

In dit licht bezien, gaat men begrijpen dat het moderne snelverkeer zich ontwikkelt in een richting waarbij 'ontmoetingen' zoveel mogelijk worden uitgeschakeld. Als voorbeelden, het eenrichtingsverkeer en de afgeschermde middenberm, verder het overheen en onderdoor leiden van kruisend verkeer. Wellicht kan men zich afvragen of wij in de toekomst niet geconfronteerd zullen worden met een snelverkeer op afzonderlijke en afgeschermde rijstroken met bijbehorende vluchtstrook en wel in file en met constante snelheid en voorgeschreven onderlinge afstand.

*

Ook bij de onderzoeker kan men in zekere zin spreken over ontmoetingen. Dit ligt op ander gebied en betreft vooral het kennis nemen van het werk van anderen, hetzij uit publikaties, correspondentie, voordrachten of besprekingen, maar ook het voldoen aan aanvragen om mededelingen te doen over eigen werk. Men kan ook hier te maken hebben met gebieden van een geringe dichtheid van onderzoek als over een bepaald onderwerp weinig mensen werken. Daartegenover staan dan de gebieden waarvoor, vaak om praktijkredenen, een grote interesse bestaat en waar de dichtheid van het onderzoek groot is. Ik denk bijvoorbeeld aan de onkruidbestrijding, waarvoor twee tijdschriften bestaan, namelijk één in Amerika en één in Europa en bovendien nog een afzonderlijk refereertijdschrift. Voor dergelijk werk is bovendien de vraag van de praktijk om contact nog een factor erbij.

Wordt de dichtheid zeer groot, dan ziet de individuele onderzoeker zich uiteindelijk geplaatst voor de mogelijkheid van een groot aantal contacten en het doorlezen van een bijna oneindige stroom van publikaties. Dit is weer hetzelfde chapiter, een tienvoud geeft per individu tienmaal zoveel leeswerk en voor het geheel dus honderd maal. Dit laatste dan te financieren door de overheid van verschillende landen. Men kan dit in een formule aldus benaderen: als n onderzoekers elk van elkaar één publikatie lezen, dan leest elke onderzoeker dus n-1 publikaties. Totaal lezen zij dan n (n-1) = $n^2$-n publikaties, een reeks die nagenoeg kwadratisch oploopt. Ik signaleer dit, omdat ik meen dat dit uiteindelijk remmend kan werken op eigen onderzoek. Natuurlijk moet men contacten hebben, maar de mate waarin is een rekbaar begrip. Op de internationale bijeenkomsten is een duidelijk streven merkbaar tot steeds verdere splitsing in secties of in symposia, waar slechts beperkte gebieden of speciale onderwerpen worden behandeld. Specialisatie en beperking kan dan een noodgedwongen besparing van tijd en energie betekenen.

In dit verband kunnen ook de werkgroep en het onderzoek in teamverband worden bekeken. De werkgroep, zoals men die in Nederland en ook elders kent, betreft meestal een groep onderzoekers, soms aangevuld met rechtstreeks belanghebbenden, bijvoorbeeld uit een Voorlichtingsdienst, die één of meer keren per jaar bijeenkomen voor bespreking van de resultaten die binnen het gebied van de werkgroep werden verkregen, dus een uitwisseling van gegevens in beperkte kring. Er dreigen hier m.i. echter twee gevaren, namelijk ten eerste dat de groep te groot wordt en ten tweede dat teveel belangstellenden die weinig over het onderwerp weten of die er niet rechtstreeks bij betrokken zijn, tot de groep toetreden. In beide gevallen kan door splitsing in subgroepen veel worden bereikt, mits gezorgd wordt dat voor deze subgroepen alleen de betrokken onderzoekers en de rechtstreeks belanghebbenden worden gevraagd.

Vervolgens het onderzoek in team-verband. Dus een coöperatie, waarbij ieder een eigen deel neemt en de publikatie gezamenlijk of in aansluiting geschiedt, met de mogelijkheid werkers uit verschillende gebieden van wetenschap te verenigen. Aan een dergelijke intensieve vorm van samenwerking liggen enige zuiver menselijke voorwaarden ten grondslag. Wijlen Professor H. R. Kruyt heeft eens gezegd dat voor een goed team nodig is: wederzijdse waardering en vertrouwen, het aanvaarden van kritiek tussen de teamleden en tenslotte de wil gezamenlijk iets tot stand te brengen. Daarbij kunnen bijzondere specialisatie en gaven tot hun recht komen zonder dat ieder het gehele gebied tot in details behoeft te beheersen.

*

In de moderne communicatiemiddelen ligt een grote kracht, maar m.i. tevens het gevaar dat wij verdwalen wanneer zij een doel in plaats van een hulpmiddel dreigen te worden. Ik wil daarbij echter het vertrouwen uitspreken in de goede onderzoeker, die, als men hem de mogelijkheid geeft en de rust gunt het project van onderzoek grondig te bewerken, zelf de weg wel vindt. Perioden met een behoefte aan veel contacten zullen bij de individuele onderzoeker af kunnen wisselen met inventieve perioden met minder behoefte aan contact. Misschien moet men achter hem staan als het er om gaat zijn tijd te verdedigen tegen anderen die daarop teveel beslag dreigen te leggen. Dit geldt in het bijzonder voor gebieden met grote dichtheid van onderzoek en vooral voor beroep uit de praktijk. Het is verheugend dat in vele gevallen de voorlichtingsinstanties de taak van de onderzoeker kunnen verlichten en zelfs in belangrijke mate aan een probleemstelling kunnen meewerken. Maar de keerzijde van de medaille is dat de voorlichtingsdiensten maar al te graag de onderzoeker in hun voorlichting willen inschakelen, waardoor zij hem van zijn eigenlijke werk afhouden.

Uit deze laatste opmerkingen zou ik willen afleiden, dat de grotere kansen op ontmoeting, vooral die op ontmoeting met de praktijk, een belasting kunnen worden voor het toegepast biologisch onderzoek. Er staan echter wegen open om de bezwaren te verkleinen met behoud van de voordelen. Vooral het bestuur van een instituut, dat er immers steeds naar zal streven het contact tussen wetenschap en praktijk in de hand te werken, dient zich m.i. ook van de bezwaren bewust te zijn. Het zal samen met de directie naar een zo gunstig mogelijke oplossing moeten zoeken.

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# I.

# GESCHIEDENIS

Dr. A. D. Voûte en J. F. de Vries Broekman

## INHOUD

## VOORLOPERS

Het Itbon is ontstaan omdat de tijd er rijp voor was. Er bestond vóór 1940 een comité dat voor de praktische bosbouw onderzoek op entomologisch gebied verrichtte, en een laboratorium te Hoenderloo dat een aan de Leidse universiteit ontwikkelde denkrichting op veldbiologisch gebied toepaste. Zij zijn bij de oprichting van het Instituut er beide in opgegaan en kunnen dus als zijn voorlopers worden beschouwd.

### *1. Comité ter Bestudering en Bestrijding van Insektenplagen in Bossen ('Insektenplagencomité')*

Een drie tot vier decennia geleden deden zich in verschillende landen van Europa ernstige insektenplagen voor. Op het 2e internationale bosbouwcongres, in 1936 te Boedapest gehouden, kwam de weerslag hiervan tot uitdrukking. De Weense hoogleraar DR. E. SCHIMITSCHEK pleitte in een inleiding klemmend voor meer en stelselmatiger onderzoek naar de oorzaak van plagen. Zijn betoog verwierf de steun van velen, wat het congres er toe leidde het volgende aan te bevelen:

1e. de studie – ter plaatse van de haarden – van alle gradaties van schadelijke insekten, welke studie dient te worden beoefend door vaklieden op het gebied van de bosbouwentomologie en centraal geleid voor een geheel land of, naar gelang van de grootte, voor een deel daarvan. De invloed van de plaatselijke omstandigheden op het gedrag der insekten moet steeds bij de haarden van de aantastingen worden bestudeerd. Terzelfder tijd moeten onderzoekingen worden verricht nopens de vraag op welke wijze de gradatie de levenskracht en de voortplanting der zich aan het einde van haar ontwikkeling bevindende soorten beïnvloedt.

Wanneer wordt het einde der ontwikkeling bereikt en welke gevolgen vloeien daaruit voort ten aanzien van de soort? Om deze arbeid – die voldoende behoort te worden gesubsidieerd door de Staat – te voltooien, moeten goed uitgeruste verplaatsbare boslaboratoria worden ingericht, die te allen tijde op de plaats der gradatie in bedrijf kunnen worden gesteld. In deze laboratoria kan men de oorzaak van het ontstaan en de ontwikkeling der gradatie en van de factoren die de crisis ten gevolge hebben, bestuderen.

2e. de stichting van vaste laboratoria in bossen, om de invloed te bestuderen van de levende en dode natuur en die van de andere factoren op het gedrag der schadelijke insekten gedurende normale jaren. Het is aanbevelenswaardig, de verdeling van de laboratoria te doen geschieden naar gelang van de onderscheidene klimaatzones. Het is noodzakelijk, dat zij zich bevinden in het middelpunt van de voornaamste banen waarlangs de trek van de insekten plaats vindt en van de gebieden die buiten gevaar zijn, en dat zij altijd zijn geplaatst te midden van de bosbezittingen. Behalve aan de studie van de biotische- moet noodzakelijkerwijs aandacht worden geschonken aan de niet-biotische factoren die de insekten en de parasieten beïnvloeden (klimaat, tijd, klimaat van de omgeving, 'micro-klimaat' enz.). De vaste en verplaatsbare laboratoria richten waarnemingsstations in ter bestudering van het verband tussen klimaat en dierlijk leven, in aansluiting met biologische onderzoekingen. Het doel van deze studiën is het vinden van de beste bosformaties en cultuurmethoden die de grootste weerstand bieden aan de schadelijke insekten, d.w.z. die de ongunstige voorwaarden scheppen voor hun ontwikkeling en hun leven.

3e. de stichting van stations voor bosonderzoek in de nog bestaande resten van het oerbos. Hun taak zou zijn de bestudering van het gedrag der voornaamste voor het cultuurbos schadelijke insekten, maar dan in oerbossen, zomede het opsporen der in dit milieu gunstig en ongunstig werkende invloeden.

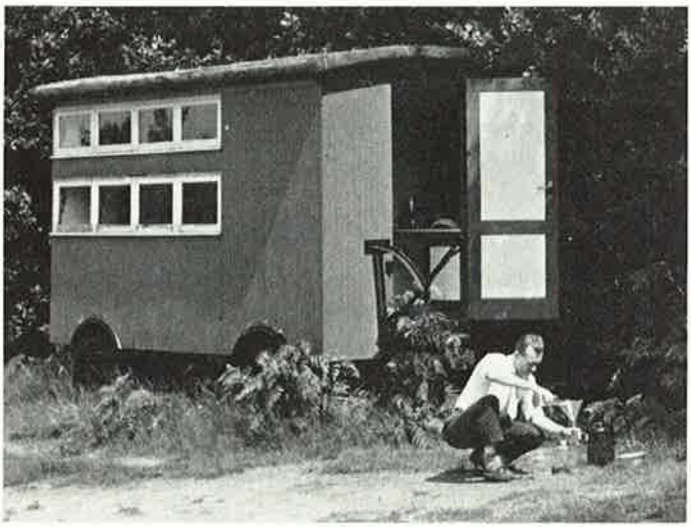
Nederland behoorde tot de landen waar omvangrijke insektenplagen waren opgetreden of het nog deden, en onze afgevaardigden op het congres (de heren DE BEAUFORT, VAN DISSEL, VAN LONKHUIJZEN, VAN TIENHOVEN) hadden de zaak dan ook met alle aandacht gevolgd. Terstond na terugkeer in ons land begon onder leiding van de heer VAN DISSEL een intensief overleg om voor ons land het bepleite onderzoek op gang te krijgen. Reeds in 1937 kwam het tot oprichting van het Comité ter Bestudering en Bestrijding van Insektenplagen in Bossen – bij afkorting Insektenplagencomité genoemd –, dat de volgende samenstelling kreeg:

E. D. VAN DISSEL, directeur Staatsbosbeheer, voorzitter;
IR. N. VAN POETEREN, hoofd Plantenziektenkundige Dienst, secretaris;
IR. J. P. VAN LONKHUIJZEN, directeur Nederlandsche Heidemaatschappij, penningmeester;
PROF. DR. JOH^A. WESTERDIJK, directrice Phytopathologisch Laboratorium 'Willy Commelin Scholten';
PROF. DR. W. K. J. ROEPKE, hoofd Entomologisch Laboratorium der Landbouwhogeschool;

Jhr. W. H. de Beaufort;
Dr. J. de Hoogh, houtvester Staatsbosbeheer, 2e secretaris.

Zodra het comité in de openbaarheid trad, begon het een actie tot werving van z.g. 'contribuanten' teneinde een vaste financiële basis voor het beoogde werk te verkrijgen. Het nam hierbij een voorbeeld aan het 'Comité inzake bestudering en bestrijding van de iepenziekte', dat in 1930 was opgericht. Bemoedigend velen lieten zich winnen: particulieren en instellingen die rechtstreeks of zijdelings belang hadden bij het in stand houden van de bossen, en voorts de overheid. Vooruitlopend op wat aan geldmiddelen zou bijeenkomen, stelde het comité in augustus van het lopende jaar alvast een jong entomoloog aan: Drs. J. Wilcke, die in maart 1938 werd opgevolgd door Ir. J. J. Fransen. Beiden hadden in opdracht van Prof. Roepke al op de Hoge Veluwe gewerkt aan de dennebladwesp *(Diprion pini)* en het was juist deze plaag die men allereerst in studie genomen wilde zien.

De reden hiertoe leest men in het begin van het rondschrijven waarmee het comité zich bij zijn totstandkoming tot de buitenwereld richtte: 'Velerlei zijn de insektenplagen die onze Nederlandse bossen en houtopstanden bedreigen. Men herinnere zich de verwoestingen welke de nonvlinder en de gestreepte dennenrups indertijd aanrichtten in de grovedennenbossen, waarbij over honderden hectaren de bomen kaal werden gevreten, zodat zij moesten worden geveld, terwijl de aanwas van grote oppervlakten bos gedurende verscheidene jaren sterk verminderde. Hetzelfde beleven wij thans, sedert het vorige jaar, van de dennebladwesp. Op tal van plaatsen zijn grote com-



Rijdend laboratorium.

Biologisch Laboratorium
'Hoenderloo'.

plexen grovedennenbos zodanig aangetast dat verschillende bosgedeelten in hun geheel moeten worden geveld of dat dunningsgewijs tal van stammen moeten worden verwijderd.'

Het Insektenplagencomité werd weldra zozeer een begrip in de Nederlandse bosbouw dat het ook na toetreding tot het Itbon, in 1940, zijn taak onverkort bleef vervullen. Hoewel de werkzaamheden geheel in die van het Itbon waren opgegaan, geschiedden de bosentomologische onderzoekingen voorlopig nog onder auspiciën van het comité. De resultaten zijn tot en met die van 1951 gepubliceerd als 'Mededelingen' van dit comité. Het Insektenplagencomité heeft tot 1959 voortbestaan. In dat jaar is het opgenomen in de 'Contactcommissie van het Itbon', een college dat in 1941 was opgericht voor samenspreking met andere instellingen.

### 2. *Biologisch Laboratorium 'De Hoge Veluwe'*

In 1938 gaf Prof. Dr. C. J. van der Klaauw, hoogleraar in de zoölogie aan de Leidse universiteit, uiting aan zijn verlangen naar een mogelijkheid om studenten praktisch te doen werken op ecologisch gebied aan problemen die zich in het veld voordoen. Hij zocht hiertoe contact met de directeur van de stichting het Nationale Park de Hoge Veluwe, Dr. A. D. Voûte. Als uitvloeisel hiervan besloot het bestuur dezer stichting een vrijgekomen opzichterswoning in Hoenderloo beschikbaar te stellen om als veldlaboratorium te worden gebruikt. De inrichting hiervan is vooral tot stand gekomen door toedoen van het bestuurslid Prof. Dr. G. A. van Poelje, die de Haagse

'Vakcursussen voor Jeugdige Werklozen' wist in te schakelen voor het vervaardigen niet alleen van het meubilair, maar ook van een rijdend laboratorium. Het instrumentarium was aanvankelijk grotendeels in bruikleen van het Zoölogisch Laboratorium te Leiden.

Het onderzoek stond onder leiding van de directeur van de Hoge Veluwe. Als eerste studieobjecten zijn gekozen de dennebladwesp en de rhododendronwants *(Stephanitis rhododendri)*, die werden bewerkt door resp. A. F. H. Besemer en mejuffrouw A. L. Schuiling. Dit waren ouderejaarsstudenten, die in Hoenderloo gedurende de zomermaanden waren gedetacheerd door het genoemde Leidse laboratorium en dan tevens assisteerden bij het toezicht op het werk der jongere studenten.

In 1939 is voor de eerste maal een cursus voor studenten in de biologie gehouden, die twee weken duurde; de deelnemers kampeerden op een terrein van het Nationale Park. De hiervoor samengestelde excursiegids mag als eerste werkstuk van het nieuwe laboratorium worden beschouwd. De eerste week werd besteed aan excursies onder deskundige leiding op de Hoge Veluwe en in de bossen in de omgeving daarvan. Gedurende de tweede werkten de deelnemers praktisch aan een probleem; de eerste maal is hiervoor genomen de verspreiding en parasitering van de dennebladwesp. Met uitzondering van het laatste oorlogsjaar zijn deze cursussen elk jaar gehouden tot en met 1962. Hierna liep de belangstelling zodanig terug, dat tot beeindiging moest worden besloten.

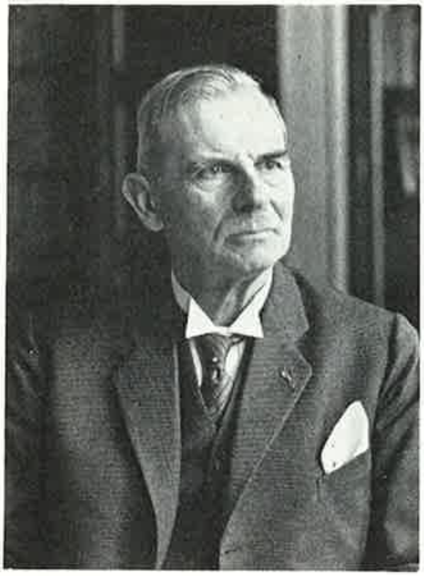
## ONTSTAAN VAN HET ITBON

Insektenplagencomité en Biologisch Laboratorium 'De Hoge Veluwe' werkten op nauw verwante gebieden en zij beschikten beide niet of ternauwernood over middelen om het onderzoek de uitbreiding te geven die nodig werd geoordeeld om tot goede resultaten te komen.

Om deze reden zocht PROF. VAN POELJE – bestuurslid van de Hoge Veluwe in zijn kwaliteit van secretaris-generaal van het Ministerie van Onderwijs, Kunsten en Wetenschappen en directeur-generaal van het Onderwijs – nog in 1939 contact met de Centrale Organisatie T.N.O. De hieruit voortkomende besprekingen, die van de zijde van T.N.O. voornamelijk werden gevoerd door haar secretaris-penningmeester, IR. A. DE MOOY A.C. ZN., leidden tot het besluit om te komen tot een nieuw T.N.O.-instituut, te noemen Instituut voor Toegepast Biologisch Onderzoek in de Natuur, waarin het Insektenplagencomité en het laboratorium 'De Hoge Veluwe' zouden samensmelten. Met dankbaarheid mogen hier als de eigenlijke oprichters worden vermeld:

PROF. DR. G. A. VAN POELJE,
IR. A. DE MOOY A. C. ZN.,
E. D. VAN DISSEL en
PROF. DR. C. J. VAN DER KLAAUW, allen voornoemd.

Vooral PROF. VAN POELJE was er zich van bewust dat in een gebied als de Hoge Veluwe een onderzoek leidend tot een beter begrip van de natuur wenselijk was. Deze zienswijze, die werd gedeeld door PROF. VAN DER KLAAUW en aanvaard door het bestuur van de Hoge Veluwe, heeft in hoge mate de doelstelling van het Itbon mede bepaald. Er werd een 'reglement' opgesteld, dat het hoofddoel als volgt omschreef: 'het toegepast-biologisch onderzoek van bossen en andere houtopstanden en niet voor land- of tuinbouw bestemde terreinen'. Aanvankelijk is hierbij speciaal gedacht aan de levensgemeenschappen in de natuur, d.w.z. aan de samenhang tussen de organismen of groepen van organismen zoals men deze buiten aantreft. Later is het concept ruimer genomen en zijn ook andere ecologische veldproblemen in het onderzoek betrokken. Na verloop van tijd, toen de banden met de Hoge Veluwe losser waren geworden en het Instituut meer landelijk werkzaam was, heeft de zojuist geciteerde taakomschrijving geleid tot de



E. D. van Dissel.

Prof. Dr. G. A. van Poelje.

Prof. Dr. C. J. van der Klaauw.

Ir. A. de Mooy A. C. zn.

opdracht aan het Itbon om op te treden als proefstation voor de woeste gronden.

In de tijd dat het een T.N.O.-instituut was, is het Itbon bestuurd door een 'Centraal Comité', waarin voor de eerste maal zitting hadden de heren PROF. DR. G. A. VAN POELJE (voorzitter), E. D. VAN DISSEL (ondervoorzitter), IR. N. VAN POETEREN (voornoemd), DR. J. A. VAN STEIJN (de nieuwe directeur van Staatsbosbeheer), PROF. DR. C. J. VAN DER KLAAUW (voornoemd), PROF. DR. J. SMIT (voorzitter bestuur Biologisch Station te Wijster) en C. VAN DEN BUSSCHE (directeur Nederlandse Heidemaatschappij). Het Insektenplagencomité werd op het ogenblik van de oprichting van het Itbon opgeheven en tegelijkertijd door het Centraal Comité ongewijzigd wederingesteld (art. 5 van het 'reglement') als zelfbesturend comité van het Itbon. Als secretaris van het Centraal Comité zou optreden de directeur van het Insektenplagencomité (art. 4) en blijkens art. 10 zou die directeur DR. A. D. VOÛTE zijn.

Als datum voor de oprichting van het Itbon werd vastgesteld 15 mei 1940. De oorlog kwam tussenbeide. Toen de communicatie in ons land was hersteld, is opnieuw een datum vastgesteld en wel 1 september. Opnieuw kon het voornemen geen uitvoering vinden, ditmaal door de gevangenneming van PROF. VAN POELJE. Tenslotte is het 25 september geworden. Bij monde van de voorzitter van de Centrale Organisatie T.N.O., DR. J. ALINGH PRINS, werd het Centraal Comité geïnstalleerd en het reglement verklaard in werking te zijn getreden.

Het Itbon begon zijn bestaan met een wetenschappelijk personeel van twee personen: DR. A. D. VOÛTE en DR IR. J. J. FRANSEN. Het overige personeel was nog geringer in aantal: de technische medewerker A. J. BARON SCHIMMELPENNINCK VAN DER OYE, die eerst werd gedetacheerd door de Hoge Veluwe, maar per 1 januari 1941 in dienst van T.N.O. trad. Het Instituut had de beschikking over het laboratorium te Hoenderloo, waarvan de naam werd gewijzigd in Biologisch Laboratorium 'Hoenderloo', terwijl de Nederlandse Heidemaatschappij in haar gebouw te Arnhem een werkruimte voor DR. FRANSEN ter beschikking stelde, zoals zij dit ook had gedaan voor het Insektenplagencomité.

Alle onderzoekingen die betrekking hadden op bosinsekten, bleven ressorteren onder dit comité, dat behalve de werkplannen ook de begroting moest beoordelen. Daar vele contributies ook nu nog speciaal ten behoeve van dit comité werden verstrekt, had het een eigen geldelijk beheer. Dit betekende, dat het Itbon en het Insektenplagencomité elk een penningmeester hadden. Toen PROF. DR. G. HOUTZAGERS van beide de penningmeester was geworden en zowel hij als de directeur overtuigd waren geraakt van de onmogelijkheid om de financiën gescheiden te houden, is de eigen financiële

Jhr. W. H. de Beaufort,
25 jaar bestuurslid.

administratie van het comité opgeheven en onder het Itbon gebracht. Wel werden de inkomsten en uitgaven onder een apart hoofd geboekt en dit is zo gebleven tot het einde van het comité. De nieuwe regeling voltrok zich in 1946 en behoorde tot een groter complex van herschikking. Zo werd toen tevens besloten een einde te maken aan de merkwaardigheid dat de jaarverslagen van het comité werden gedrukt, terwijl die van het Itbon slechts werden getypt voor intern gebruik.

## VOLGENDE JAREN

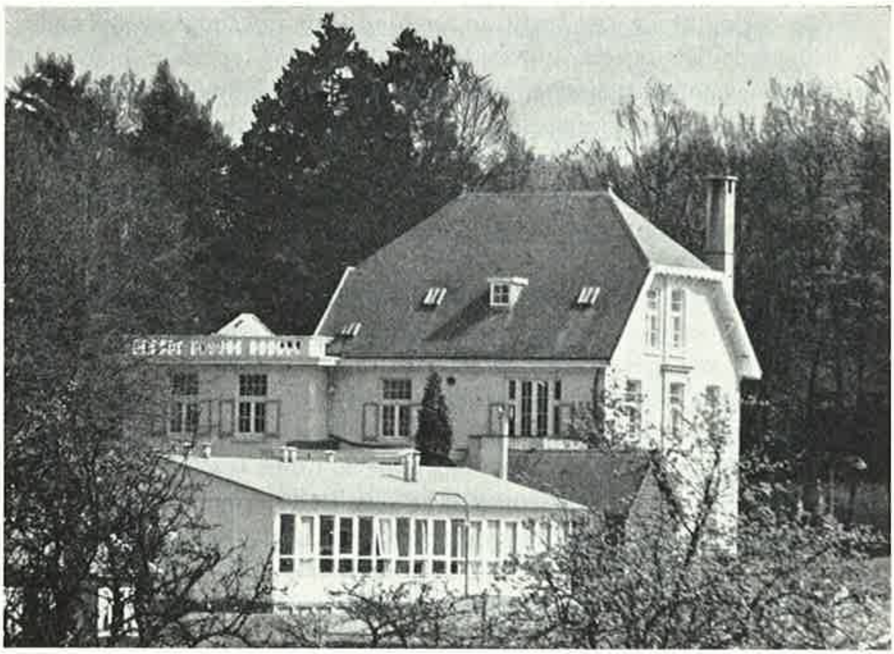
Toen de bezetters de Leidse universiteit hadden gesloten, nam T.N.O. het personeel van het Zoölogisch Laboratorium in dienst en detacheerde het met ingang van 1 januari 1942 bij het Itbon. Dit betekende dat de staf met drie onderzoekers werd uitgebreid: Dr. Maria Rooseboom, Drs. J. van der Drift en Drs. R. J. van der Linde. Hierdoor konden naast de bosentomologie twee nieuwe terreinen in het onderzoek worden opgenomen: bodemfauna en houtwallen, later windschermen genoemd.

Nadat de Nederlandse Heidemaatschappij door plaatsgebrek gedwongen werd de aan Dr. Fransen ter beschikking gestelde werkruimte voor andere doeleinden te gebruiken, huurde het Itbon in het perceel Floris Versterstraat 54 te Arnhem twee vertrekken, die tot laboratorium werden ingericht. Voorlopig vond nu geen verdere uitbreiding van het Instituut meer plaats, noch wat de werkruimte, noch wat de personeelsformatie betreft. Naarmate de oorlog voortduurde, werden de werkzaamheden er steeds meer door belemmerd. In het begin konden zij nog overal in het land worden verricht. De onderzoekers waren vrij beweeglijk; auto's waren niet beschikbaar, maar grote afstanden werden per fiets afgelegd. Geleidelijk aan werd het reizen moeilijker, daar de treinen werden gebombardeerd en het jeugdige mannelijke personeel zich niet ongestraft op de wegen kon bevinden. Het veldwerk werd dan ook meer en meer tot de naaste omgeving van het laboratorium beperkt. Na de landingen van de geallieerden in Frankrijk werden de mogelijkheden nog weer aanzienlijk geringer, omdat hoe langer hoe meer beperkingen aan het gebruik van de terreinen werden opgelegd. Na september 1944 werden vrijwel alle bossen en heiden van de Hoge Veluwe verboden gebied. Tot mei 1945 zijn de beide laboratoria gesloten geweest; de boekerij en het instrumentarium werden ondergebracht in een ondergrondse betonnen ruimte te Hoenderloo. Toch is nog naar nuttig werk gestreefd. In een daartoe te Otterlo ingericht klein laboratorium werd namelijk op verzoek van het Rode Kruis een onderzoek verricht tot bestrijding van de klerenluis, dit met het oog op straks uit Duitsland terugkerende tewerkgestelden en gevangenen. Een methode is uitgewerkt die overal zou zijn toe te passen met algemeen aanwezig materiaal (blikken, gaarkeukenketels, scheergerei). Dit is echter nimmer behoeven te geschieden dank zij het ter beschikking komen van DDT.

Mariëndaal.

Na de oorlog kwam ons Instituut terstond in huisvestingsmoeilijkheden. De genoemde laboratoriumruimte te Arnhem ging verloren omdat het perceel als woonhuis moest worden gebruikt en ook het onderkomen in Hoenderloo dreigde verloren te gaan daar de Hoge Veluwe het wilde toewijzen aan een gepensioneerde jachtopziener. Uitkomst kwam doordat 'Het Gelders Landschap' het landhuis Mariëndaal te Oosterbeek ter beschikking stelde mits het gerestaureerd werd, – een voorwaarde die T.N.O. aanvaardde. Het gebouw was echter te groot voor het toenmalige Itbon en bij gevolg kregen wij er inwoning van het Bedrijfslaboratorium voor Grondonderzoek. De samenwoning met deze instelling is steeds bijzonder prettig geweest, maar wel moet worden gezegd dat wij een koekoeksjong in ons nest hadden gekregen. Het Bedrijfslaboratorium groeide snel, zodat het weldra alle nog vrije ruimte nodig had, ja zelfs moest bijbouwen. Hierdoor bleef voor het Itbon geen verdere groeimogelijkheid over. Enige tegemoetkoming gaf, dat de Hoge Veluwe het koetshuis van het afgebroken landhuis Kemperberg ter beschikking stelde in plaats van 'Hoenderloo'. Onder de benaming 'Veldlaboratorium Kemperberg' wordt het tot op heden intensief gebruikt. Het was echter alleen geschikt voor 's zomers en daarom te meer gaf het maar zeer ten dele verlichting. De impasse werd eerst overwonnen toen T.N.O. het landhuis de Sylvahoeve kocht, gelegen in Schaarsbergen, gemeente

Veldlaboratorium Kemperberg.



Sylvahoeve.

Arnhem. Het Itbon kon er op 12 december 1954 zijn intrek nemen. Wederom kreeg het inwoning, en wel van het Instituut voor Oecologisch Onderzoek (I.O.O.), een instelling van de Koninklijke Nederlandse Akademie van Wetenschappen. Hieraan stonden wij twee vertrekken af, hetgeen na verloop van tijd voor dat instituut niet genoeg meer was en voor het onze te veel. Wij kregen er in 1959 een barak bij en voor het I.O.O. kwam er in 1964 op het terrein van het landgoed een eigen gebouw. Hierin werden ons tijdelijk een groot laboratorium en twee werkkamers ter beschikking gesteld, in afwachting van het nieuwe gebouw dat voor ons instituut in de pen was. Na langdurige voorbereidingen kwam een ontwerp gereed voor aanbesteding en gunning. Op 28 juni 1965 kon met het grondwerk worden begonnen. De bouw zal wel twee jaar vergen.

Tegelijk met de behoefte aan ruimte groeide uiteraard die aan personeel. Assistenten waren er in de beginjaren niet dringend nodig, omdat nog weinig routinewerk was te verrichten. Studenten werden ingeschakeld voor de meer eenvoudige werkzaamheden. Omstreeks 1946 echter was sommig onderzoek al zover gevorderd dat middelbare krachten een groot deel van het werk konden uitvoeren. Bovendien verruimde in de loop der jaren het te onderzoeken gebied, zodat nieuwe onderzoekers moesten worden aangetrokken. Ons personeel groeide van 3 personen in 1941 en 7 vlak na de oorlog (zie foto) tot 55 thans.

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In 1946 werd het z.g. Iepenziektecomité in het Itbon opgenomen als zustercomité van het Insektenplagencomité. Dit ging gepaard met een naamsverandering in dier voege dat behalve iepen ook andere boomsoorten op het program konden komen. Reeds de 'Verslagen over 1944 en 1945' zijn een uitgaaf van het Itbon geworden. Ook dit comité was zelfbesturend met eigen begroting en eigen jaarverslag. De secretaris van het Centraal Comité van het Itbon werd er secretaris van. De plaats der werkzaamheden bleef bij voortduring Baarn. Met ingang van 1956 is het comité ingedeeld bij het Bosbouwproefstation 'De Dorschkamp' T.N.O. Wegens de korte tijd dat het Iepenziektecomité tot het Itbon heeft behoord, zal in deze publikatie niet op zijn werk worden ingegaan.

Het Itbon zelf heeft in 1948 opgericht het Comité voor Jachtonderzoek en het Comité voor Duinonderzoek. Ook zij waren zelfbesturend. Deze comité's zijn nooit opgeheven, maar in feite bestaan ze niet meer. De werkzaamheden van het ene zijn opgegaan in onze afdeling Wildbiologie, die van het andere in de afdeling Landschapsecologie.

Al deze zelfbesturende comité's hadden mede tot taak om belangstelling van de belanghebbenden te wekken en hen tot het verlenen van bijdragen te

Het voltallige personeel kort na de oorlog: Drs. J. van der Drift, A. J. baron Schimmelpenninck van der Oije, mejuffrouw J. Keus, Drs. R. J. van der Linde, Dr. A. D. Voûte en Drs. E. T. G. Elton.

stimuleren. In tegenstelling tot andere gevallen slaagde dit niet voldoende ten aanzien van het wildonderzoek. Particulieren en instanties die zich op het gebied van jacht en natuurbescherming bewogen, bleven slechts in bescheiden mate bijdragen. Gelukkig bleek in 1954 de toenmalige directeur van de afdeling Wild- en vogelschade en Jacht (later 'Directie Faunabeheer') van het Ministerie van Landbouw, Visserij en Voedselvoorziening, de heer W. J. SCHUITEMAKER, bereid gelden uit te trekken voor intensivering van het onderzoek. Een jaar daarop deed ook het Jachtfonds, waarvan de heer SCHUITEMAKER voorzitter was, een aanzienlijke bijdrage. Later nam het Jachtfonds de gehele financiering op zich. Gedurende het optreden van IR. C. H. J. MALIEPAARD in de beide functies zijn de bijdragen nog toegenomen, waardoor het wildonderzoek zich tot zijn huidige vorm kon ontwikkelen. Thans financiert het fonds wel niet meer het gehele onderzoek, maar nog steeds ontvangen wij een belangrijke en voor ons werk noodzakelijke steun.

In de duinen heeft het Itbon veel onderzoek gedaan voor rekening van duinwaterleidingmaatschappijen. Aanvankelijk gebeurde dit onder supervisie van het genoemde Comité voor Duinonderzoek.

Toen het Itbon onder het Ministerie ging ressorteren, werd het steeds moeilijker om bijdragen van particulieren te krijgen. Toch bleek contact met deze groep van belanghebbenden noodzakelijk. Om deze redenen is afgestapt van het stelsel van zelfbesturende comité's en is overgegaan tot het oprichten van discussiegroepen. Zo is in 1961 ingesteld een 'Discussiegroep Wildproblemen', waarin onderzoekers en jagers wildproblemen en jacht bespreken. Dit comité heeft reeds veel bijgedragen tot een goed begrip tussen onderzoekers en belanghebbenden op dit gebied. Een ouder voorbeeld is de van 1946 daterende 'Contactcommissie van het Itbon', waarin instellingen zowel uit de sector van de praktijk als van het onderzoek vertegenwoordigd waren. In dit geval is de belangstelling niet duurzaam gebleken.

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Had tot 1949 het Itbon rechtstreeks gestaan onder de Centrale Organisatie T.N.O., in dat jaar werd het administratief ondergebracht bij de Landbouworganisatie T.N.O. In feite behoorde het reeds eerder hiertoe, daar de voorzitter van laatstgenoemde Organisatie als lid van het dagelijks bestuur der Centrale Organisatie was belast met de bemoeienissen met het Instituut.

Aan de periode gedurende welke het Itbon onder T.N.O. heeft geressorteerd, dat is tot midden 1957, behouden wij een prettige herinnering, wat zeker niet in de laatste plaats te danken was aan de toewijding waarmee onze belangen steeds zijn behartigd. Het is niet doenlijk hier allen te noemen aan wie wij verplichtingen hebben. Een uitzondering mag echter worden gemaakt voor een viertal T.N.O.-functionarissen met wie wij een uiterst veelvuldig en steeds stimulerend en nuttig contact hebben gehad, t.w. IR. A. DE MOOY A. C. ZN., voornoemd, PROF. DR. O. DE VRIES, voorzitter, IR. C. VAN DER GIESSEN, secretaris, en mejuffrouw B. M. VAN LENNEP, adjunct-secretaris van de Landbouworganisatie T.N.O.

In 1957 is overgegaan tot een grondige reorganisatie van het landbouwkundig onderzoek in ons land. De Landbouworganisatie T.N.O. werd opgeheven en vervangen door de Nationale Raad voor Landbouwkundig Onderzoek T.N.O. Alle betrokken instellingen van onderzoek werden autonome ministeriële stichtingen ressorterend onder de Directie van de Landbouw van het Ministerie van Landbouw, Visserij en Voedselvoorziening; alleen het Itbon kwam te behoren tot de afdeling Algemene Zaken van die Directie. Thans behoren vrijwel al deze stichtingen tot de Hoofddirectie Landbouwvoorlichting en Onderzoek van de Directie van de Landbouw. De genoemde Nationale Raad, die de minister adviseert over het gehele landbouwkundige onderzoek in ons land, coördineert ook de werkzaamheden van het Itbon met die van de andere instituten en adviseert over begroting en werkplannen.

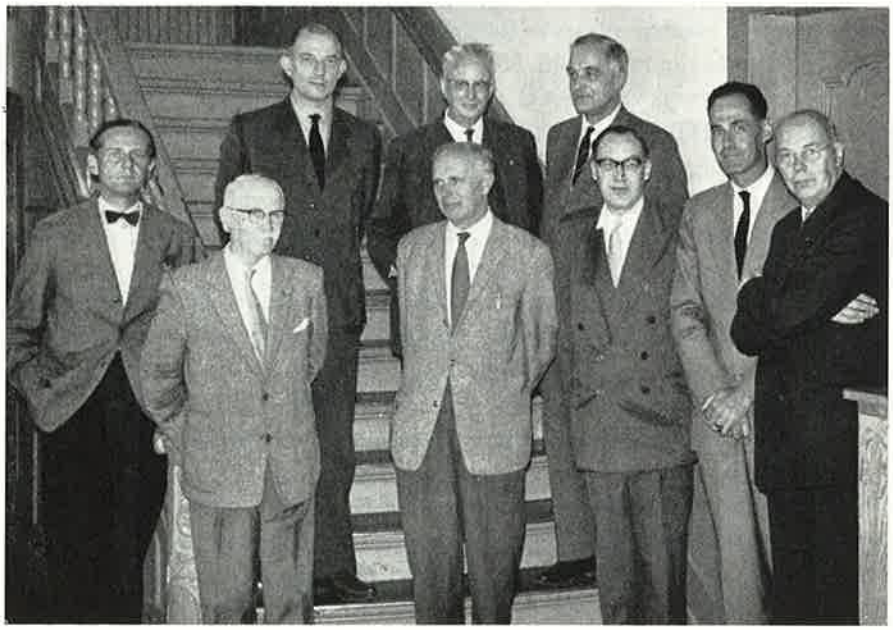
De reorganisatie is nog niet geëindigd. Een aantal vraagstukken wacht nog op een oplossing.

*

In de stichtingsacte van 1957 hield men er rekening mee dat het Itbon sinds zijn oprichting aanzienlijk was geëvolueerd. In overeenstemming hiermee werd bij behoud van de oude taak, d.w.z. in het bijzonder die van proefstation voor de woeste gronden, zijn opdracht uitgebreid tot 'de bevordering van de landbouw in de ruimste zin des woords', te verrichten door onderzoek op biologisch gebied. Hierbij werd gedacht aan: levensgemeenschappen in cultuur- en natuurgebieden; ecologische bestrijding van insektenplagen; flora en fauna van woeste gronden, bossen en voor recreatief gebruik in aanmerking komende gronden; een redelijke wildstand, gepaard gaande met verzoening van de landbouwbelangen.

Tegelijk met de verandering van status van het Instituut is het Centraal Comité vervangen door een bestuur van overwegend dezelfde samenstelling. Deze is thans:

Erevoorzitter: PROF. DR. G. A. VAN POELJE (als voorzitter afgetreden in 1960 bij de viering van het 20-jarig bestaan van het Instituut).



Laatste bestuursvergadering met de scheidende voorzitter. Eerste rij: Jhr. Mr. D. A. W, van Tets van Goudriaan, Prof. Dr. G. A. van Poelje, Dr. Ir. J. de Hoogh, Ir. J. W. Hudig, J. Melse, Ir. P. A. den Engelse; tweede rij: Ir. W. E. Meyerink, Dr. P. M. L. Tammes. Dr. A. D. Voûte.

Leden: Dr. P. M. L. Tammes, Plantenziektenkundige Dienst, voorzitter; Ir. J. W. Hudig, Landbouwschap, ondervoorzitter; Dr. Ir. L. J. van Dijk, inspecteur Directie Akker- en Weidebouw; Ir. D. Sikkel, inspecteur Staatsbosbeheer; Ir. C. H. J. Maliepaard, voorzitter Jachtfonds; Ir. W. E. Meyerink, houtvester Koninklijke Nederlandse Heidemaatschappij; Mr. F. Oorthuys, hoofd afdeling Natuurbescherming van het Ministerie van Onderwijs, Kunsten en Wetenschappen; Jhr. Mr. D. A. W. van Tets van Goudriaan, voorzitter Bosschap.

Adviserende leden: Jhr. W. H. de Beaufort; Prof. Dr. C. J. van der Klaauw.

Dagelijks bestuur: de heren Tammes, Hudig en Maliepaard.
Secretaris: de directeur van het Itbon.

Het bestuur heeft spoedig na zijn intrede een college weten te vormen voor het uitbrengen van advies over de werkplannen en over het onderzoek. Aan deze z.g. Raad voor Advies is verleden jaar ontvallen Prof. Dr. C. H. Edelman, hoogleraar in de bodemkunde aan de Landbouwhogeschool. Overigens is de samenstelling gebleven zoals zij reeds in 1958 was:
Prof. Dr. C. J. van der Klaauw, voorzitter; Prof. Dr. L. C. P. Kerling, directeur Phytopathologisch Laboratorium 'Willie Commelin Scholten' te Baarn; Prof. Dr. D. J. Kuenen, hoogleraar algemene zoölogie te Leiden; Prof. Dr. E. G. Mulder, hoogleraar microbiologie te Wageningen; Prof. Dr. J. de Wilde, hoogleraar entomologie te Wageningen.

*

De geringe mogelijkheid tot personeelsuitbreiding sinds 1957 heeft de ontwikkeling van ons Instituut een tijdlang ernstig in de weg gestaan. Deze periode kwam net op het ogenblik dat opnieuw behoefte was ontstaan aan het aantrekken van middelbare krachten. Gelukkig konden twee T.N.O.-werkgroepen het nodige personeel bij ons detacheren, waardoor de moeilijkheden althans grotendeels werden opgelost. Afgezien van het genoemde inconveniënt mag worden vastgesteld dat de samenwerking met de Hoofddirectie Landbouwvoorlichting en Onderzoek even plezierig is als voorheen die met de Landbouworganisatie T.N.O. en dat het onderzoek niet onder de reorganisatie heeft geleden. In het bijzonder mag hier de medewerking worden gememoreerd die wij ontvingen voor de verwezenlijking van de plannen voor een nieuw gebouw.

Ook een aantal inwendige reorganisaties zijn wenselijk gebleken. De groei van de werkzaamheden maakte het nodig een nauwere binding te verzekeren tussen de onderzoekers die gezamenlijk één probleem bewerken. In 1956 werden daarom afdelingen gevormd, en wel de volgende vier: Bovengrondse levensgemeenschappen, Levensgemeenschappen van de bodem, Wildschade en beheer van de wildstand, en Insektenplagen in bossen. Later is op het begrip levensgemeenschap minder nadruk gelegd, hetgeen een van de redenen was om tot naamsveranderingen over te gaan. Thans is er een afdeling Bodembiologie (hoofd DR. J. VAN DER DRIFT), een afdeling Populatie-dynamica (onder leiding van PROF. DR. H. KLOMP), een afdeling Landschapsecologie (hoofd DR. R. J. VAN DER LINDE) en een afdeling Wildbiologie (hoofd J. A. EYGENRAAM). Een afdeling Plagen, waarin de onderzoekingen over schadelijke vogels en insekten worden verenigd, is in wording. Daar het wenselijk bleek de directeur te ontlasten van het toezicht op de administratie, is een afdeling Algemene Zaken opgericht (hoofd E. SITTROP).

*

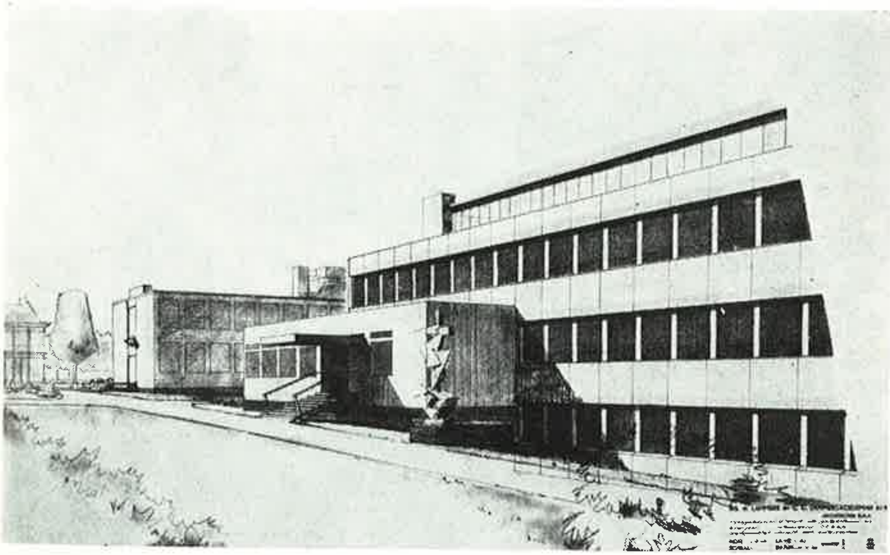
Een instituut met een zo uitgebreid en toch samenhangend gebied van onderzoek heeft bij zijn werk uit de aard der zaak vele aanrakingspunten met andere instituten. Om deze reden is steeds gestreefd enerzijds naar samenwerking, anderzijds naar een redelijke afbakening van de projecten van onderzoek. Zo werken wij met een groot aantal andere instellingen samen in een 'Werkgroep Harmonische Bestrijding van Plagen T.N.O.'. Ons gehele onderzoek betreffende de populatie-dynamica en dat over de invloed van de voedselplant op het ontstaan van een plaag valt binnen het kader van deze werkgroep. Op het gebied van de bodembiologie nemen wij deel aan het werk van de 'Contactcommissie Biologische Bodemverbetering T.N.O.', waarbinnen de onderzoekers van eveneens een groot aantal instituten over hun werkzaamheden op bodembiologisch gebied van gedachten wisselen. Met het Rivon (Rijksinstituut voor veldbiologisch onderzoek ten behoeve van het natuurbehoud) is het tot een duidelijk omschreven taakverdeling gekomen. Het Rivon onderzoekt de beschermde dieren, het Itbon de dieren die onder de Jachtwet vallen. In verband met het natuurbehoud onderzoekt het Rivon een aantal jachtdieren, echter na overleg met het Itbon, en daarentegen onderzoekt het Itbon vogels die schadelijk zijn voor landbouw en verkeer, teneinde de schade te kunnen voorkomen, althans te bestrijden.

Uiteraard sluit de zojuist besproken samenwerking en taakverdeling een nauw contact met andere instellingen niet uit. Integendeel werken wij geregeld, en soms intensief, met nog weer andere laboratoria en instituten samen over problemen die om oplossing vragen.

# IN VELD EN LABORATORIUM

Het Itbon is een instituut voor veldecologisch onderzoek, wat wil zeggen dat het begrijpen van hetgeen in het veld geschiedt doel is van het onderzoek. Dit houdt echter geenszins in, dat het gehele onderzoek buiten moet geschieden. Voor het verkrijgen van een goed begrip toch is het gewoonlijk niet voldoende dat men zich bepaalt tot het doen van waarnemingen in het veld en het trekken van conclusies hieruit. In de meeste gevallen is het nodig proeven in het laboratorium te nemen onder geconditioneerde omstandigheden en deze te vergelijken met hetgeen buiten wordt waargenomen. Daarnaast is veel analyse benodigd van buiten genomen monsters. Een laboratorium is dus voor dit soort van onderzoekingen noodzakelijk. Het daar verrichte onderzoek mag echter nooit doel in zich zelf worden, het dient als steun voor het buitenwerk.

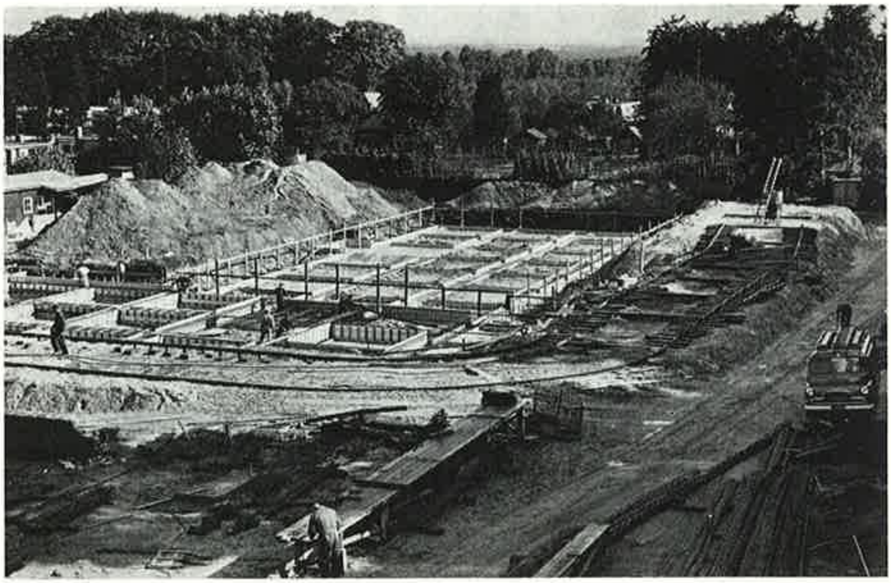
Aanvankelijk kon het Itbon toe met een zeer eenvoudig ingericht laboratorium. Het veldwerk had nog niet zoveel gegevens opgeleverd dat dit het opzetten van grote laboratoriumproeven rechtvaardigde. Een gewone en een



Situatieschets van ons nieuwe gebouw (architectenbureau Ir. H. Lammers en Ir. C. Ch. Lammers-Koeleman). Op de achtergrond het I.O.O. en de Sylvahoeve.

eenvoudige binoculaire microscoop, enige eenvoudige weeg- en meet-apparatuur alsmede kweekbakken en -flessen voor het opkweken van insekten voldeden volkomen aan de behoeften. Geleidelijk aan vroeg deze apparatuur om de nodige uitbreiding: betere microscopen, w.o. met fase-contrast, zeer nauwkeurige weegapparatuur, goed werkende thermostaten, zuurkasten en veel uitgebreider kweekmogelijkheden voor veel meer diersoorten. Ook werd het noodzakelijk over een behoorlijke fotografische apparatuur te beschikken. Bovendien ging het microbiologische en het mycologische onderzoek eigen typen van laboratoria vragen. In het meeste van het hoognodige is op den duur voorzien kunnen worden. Een typisch voorbeeld van provisorische oplossing geven de klimaatkamers die enige jaren geleden in een oude kas zijn ingericht.

Thans staan wij op het punt een fase der ontwikkeling af te sluiten en verrijst een nieuw gebouw met laboratoria die zullen voldoen aan de hoge eisen van thans. Hiertoe behoren in de eerste plaats klimaatkamers die beantwoorden aan de behoeften; voorts onder meer trilvrije tafels, niet slechts voor het wegen, maar ook voor het bepalen van de activiteitsperioden van kleinere dieren. Ook in de toekomst echter zal het veldwerk onverminderd primair zijn en heeft het laboratorium een hierop aansluitende taak. Doel blijft het begrijpen van wat zich in het veld afspeelt teneinde te kunnen nagaan welke mogelijkheden er zijn om op zo efficiënt mogelijke wijze te kunnen ingrijpen waar dit nodig is.



De bekisting voor de fundamenten nadert haar voltooiïng (foto 2 september 1965).

# BIBLIOTHEEK

Bij de oprichting van het Itbon werd de boekerij van de directeur naar het Instituut overgebracht en nog lange tijd vormden deze boeken, tijdschriften en separaten de kern van onze bibliotheek. Pas na de oorlog ging het eigen bezit zich in toenemend tempo uitbreiden.

Toen het Instituut naar de Sylvahoeve werd overgebracht en wij inwoning kregen van het Instituut voor Oecologisch Onderzoek zijn de bibliotheken van onze beide instellingen verenigd, met als eerste bibliothecaris mevrouw W. I. Temme-Radstake. Zij heeft er voor gezorgd niet alleen dat de bibliotheek bevat hetgeen mag worden verwacht voor twee instellingen die zich toeleggen op veldecologisch onderzoek, maar bovendien dat de in de boekerij aanwezige boeken, separaten en ook tijdschriftartikelen gemakkelijk zijn terug te vinden door middel van de auteurscatalogus en de systematische catalogus volgens U.D.C. Op 1 juli 1965 bedroeg het bezit aan lopende periodieken ca. 500, aan boeken ca. 2250 en aan overdrukken ca. 20.000.

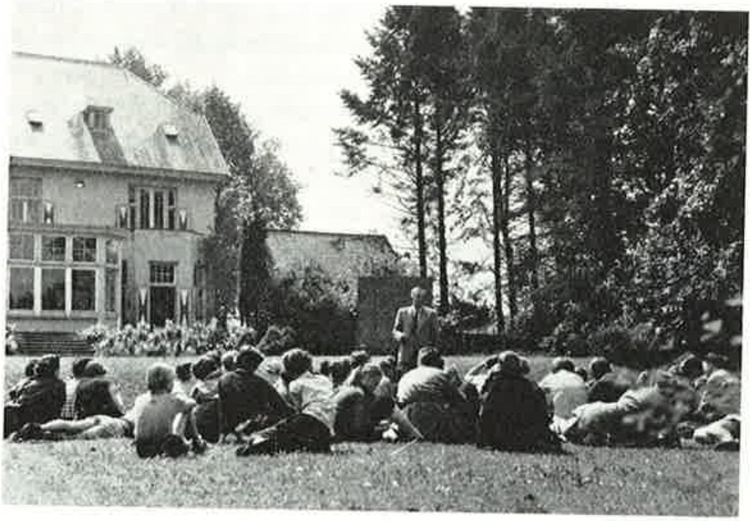
De bibliotheek heeft goede contacten met andere bibliotheken, vooral met die van Wageningen. Door de eigen onderzoekers wordt de bibliotheek uit de aard der zaak veelvuldig gebruikt, en steeds meer worden ook van buiten boeken enz. ter leen gevraagd.


1e 'Mededeling' van het Itbon (1943). Formaat 23,8 × 15,9 cm, kleur grijs.

## ONDERWIJSTAAK

De onderwijstaak van het Itbon komt voort uit die van de tweede 'voorloper', het Biologisch Laboratorium 'De Hoge Veluwe'. Dit werd immers opgericht om studenten in de zoölogie te Leiden gelegenheid te geven zich te bekwamen in het onderzoek van veldbiologische problemen.

Al spoedig kwamen ook studenten van andere universiteiten en van de Landbouwhogeschool om doctoraal- of ingenieursonderwerpen te bewerken. Ook zijn enkele proefschriften op deze wijze tot stand gekomen.



Cursus in de openlucht.

Over het algemeen hebben deze studenten onderzoekingen uitgevoerd die pasten in het werk van het Instituut. Dit heeft tot gevolg, dat bijna geen studentenwerk verloren gaat. De resultaten toch, wanneer zij niet geschikt of te onvolledig zijn om door de betrokken student te worden gepubliceerd, worden in het werk van de onderzoekers geïncorporeerd. Vooral is dit geschied bij het onderzoek op populatie-dynamisch gebied en bij dat naar het bemieren van de bossen.

Zoals reeds is vermeld, organiseerde het Instituut vele jaren een zomercursus, waaraan steeds door 30-40 studenten werd deelgenomen. Een voordeel van deze cursus was, dat er zowel biologen als Wageningers aan deelnamen, hetgeen de discussies zeer ten goede kwam. Na het overlijden in 1957 van PROF. HOUTZAGERS, die de deelneming steeds stimuleerde, verdween het Wageningse contingent uit de deelnemers. Enkele jaren later verminderde ook de belangstelling van de universiteiten, hetgeen in 1963 leidde tot stopzetting van de cursus. Mocht in de toekomst de belangstelling weer groter worden, dan zal het Itbon gaarne opnieuw een cursus organiseren.

Een gastenpaviljoen biedt aan studenten en anderen een goedkoop en prettig onderdak.

# ONTWIKKELING VAN HET ONDERZOEK

Een uitvoerige uiteenzetting over de ontwikkeling van het onderzoek van het Itbon gedurende de eerste kwart eeuw van zijn bestaan is verderop te vinden in de verhandeling 'Research'. In dit hoofdstuk worden daarom slechts de hoofdzaken besproken.

De algemene doelstelling van het onderzoek is in de loop der jaren niet of nauwelijks gewijzigd, ondanks het feit dat het opstellen van nieuwe statuten, in 1957, gepaard ging met een andere formulering. Die doelstelling is steeds geweest: toegepast ecologisch veldonderzoek, waarbij aanvankelijk de meeste aandacht uitging naar de levensgemeenschappen zoals deze zich in het veld voordoen. Wel waren er veranderingen in de praktijk van het onderzoek: het is geïntensiveerd en het terrein der werkzaamheden is uitgebreid. Ook problemen die niet rechtstreeks op levensgemeenschappen betrekking hebben, worden onderzocht, zo bijvoorbeeld de schade die wild en insektenplagen aan de bossen toebrengen, de invloed van bepaalde bodemorganismen op de omzetting van organische stof en de invloed van regenwormen op de bodemstructuur.

In het begin was het gehele onderzoek gericht op de bosbouwentomologie. Dit onderzoek is tot op de huidige dag voortgezet. Van de soorten die massaal optraden, werden er verscheidene min of meer diepgaand onderzocht: dennebladwesp (Besemer, Fransen, Hein, later Doom), dennelotrups (Voûte en Walenkamp), lariksmot (Voûte en ter Pelkwijk), bastaardsatijn- en satijnvlinder (Fransen, later Doom), junikever (Blankwaardt) en de grote dennesnuitkever (Elton c.s.). Voor een aantal soorten kon een bestrijding worden aangegeven. Bovendien maakten achtereenvolgens Blankwaardt en Doom een speciale studie van insekten, schadelijk aan populier, hetgeen noodzakelijk was geworden door de intensivering en grote uitbreiding van de populierenteelt na de oorlog. Voor de vraag of een bestrijding al dan niet lonend zou zijn, heeft eerst Fransen bij populier en later Luitjes bij lariks en groveden gewerkt. Luitjes berekende het verlies aan houtproduktie bij verschillende graden van vreterij en ging daaruit na hoeveel ten koste mag worden gelegd aan de bestrijding.

Teneinde het contact met de bosbouwers te versterken en hen in te schakelen bij het signaleren van plagen, was op instigatie van Fransen reeds in 1939 een waarnemersorganisatie in het leven geroepen. Dank zij deze organisatie ontvangen wij nog steeds uit het gehele land berichten over aantastingen. Onder de meer dan honderd medewerkers zijn vele boseigenaren en voorts ambtenaren van plantsoendiensten, de Nederlandse Heidemaatschappij, Staatsbosbeheer, de Plantenziektenkundige Dienst en Natuurmonumenten. De langs deze weg verkregen gegevens zijn voor het werk steeds van belang geweest. Ook kunnen wij met behulp hiervan een jaarlijks overzicht van opgetreden plagen publiceren.

Ter bestrijding van schadelijke bosinsekten heeft ELTON een uitgebreid onderzoek ingesteld naar de mogelijkheid om onze bossen van meer mieren te voorzien. Het lijkt of elders, met name in Duitsland en b.v. ook in Italië, de perspectieven gunstiger zijn. Ook andere sociale insekten zijn onderzocht: hommels in verband met de bestuiving vooral van rode klaver, en wespen wegens het feit dat zij jacht maken op vele schadelijke insekten in onze bossen.

Al spoedig zijn drie groepen van onderzoek toegevoegd aan het zojuist besprokene: houtwallen (op instigatie van de heer VAN DISSEL), populatie-dynamica en bodemfauna, deze laatste twee in aansluiting aan ons onderzoek over schadelijke bosinsekten.

De opdracht voor het houtwallenonderzoek was zodanig gesteld dat zij slechts vrijheid gaf om de invloed van het klimaat op het achterliggende terrein na te gaan. Hiertoe werd contact gezocht met het Koninklijk Nederlands Meteorologisch Instituut, hetgeen resulteerde in een volledige samenwerking voor dit onderzoek en voorts leidde tot enige gemeenschappelijke publikaties (DR. J. P. M. WOUDENBERG en onzerzijds VAN DER LINDE). Pas veel later kregen wij toestemming om ons oorspronkelijk plan ten uitvoer te brengen en de invloed te bestuderen van houtwallen – later windschermen genoemd – op de opbrengst van cultuurland. Er werd voor enkele gewassen een gunstig tot zeer gunstig effect waargenomen ten opzichte van de produktie (VAN RHEE, SYED RIAZ HUSSAIN SHAH). Thans is het stadium bereikt, dat praktijkproeven in verschillende delen van het land en voor verschillende gewassen kunnen worden genomen om na te gaan in hoeverre windschermen lokaal van nut zijn. Dit is echter niet meer het werk van het Itbon, maar van landbouw- en tuinbouwconsulenten. Nu het onderzoek is afgesloten, heeft VAN DER LINDE een overzicht opgesteld van de resultaten.

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Het bosinsektenwerk leerde ons, dat onze kennis in twee richtingen tekort schoot: wij wisten te weinig af van de oorzaken van het massale optreden van insekten, inclusief de invloed van de bodemfauna hierop. Dit resulteerde in het entameren van een onderzoek op fundamenteel populatie-dynamisch gebied. TINBERGEN begon in 1942 met het bestuderen van de invloed die vogels als predator hebben bij verschillende prooidichtheid. KLOMP, die hem in 1949 opvolgde, ging na hoe een insekt dat steeds talrijk is, maar nooit een plaag vormt, in zijn aantallen wordt gereguleerd. Hiertoe is gekozen de dennespanrups, *Bupalus piniarius*. Na het vertrek van KLOMP heeft GRUYS sinds 1959 het onderzoek in samenwerking met hem voortgezet en verder uitgebouwd. Het verkeert thans in een vergevorderd stadium.

Dit onderzoek is niet slechts voor de bosbouw van belang, maar ook voor een harmonische bestrijding van insektenplagen in land- en tuinbouw. Het wordt thans dan ook uitgevoerd binnen de werkgroep voor harmonische bestrijding van plagen. Hierbij worde opgemerkt dat harmonische bestrijding nieuw is voor land- en tuinbouw, maar reeds lang een methode is waarnaar de bosbouw streeft. De resultaten die ons Instituut in deze richting heeft behaald, zijn onlangs, samen met de uit de literatuur bekende, door VOÛTE in een Amerikaans tijdschrift behandeld uit een oogpunt van harmonische bestrijding van schadelijke bosinsekten.

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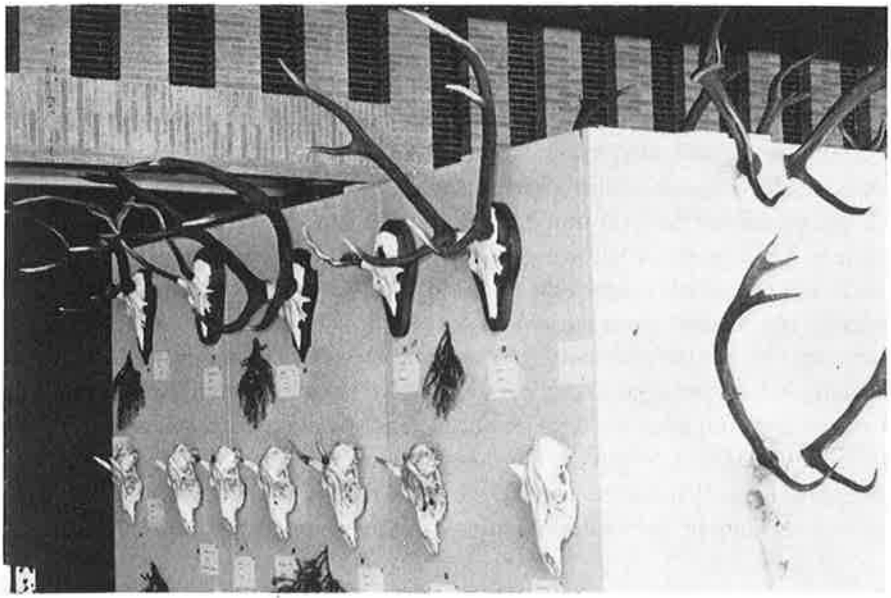
Toen de populatie-dynamica tot een zekere ontwikkeling was gekomen, voelde het Itbon de behoefte om de verkregen zienswijze ook op ander gebied toe te passen. Hieruit ontstond in 1948 het wildonderzoek. Het heeft zich beziggehouden met korhoenders (EYGENRAAM), patrijzen en fazanten (DOUDE VAN TROOSTWIJK), herten (EYGENRAAM), reeën en zeehonden (VAN HAAFTEN) als objecten van jacht en natuurbescherming en ook met z.g. schadelijke vogels als de houtduif (DOUDE VAN TROOSTWIJK) en andere soorten (STORTENBEKER).

Over het hertenonderzoek mag worden opgemerkt, dat het bekende rapport van de Commissie Hertenreservaten mede berustte op de resultaten van het onderzoek door het Itbon verricht. Uit de aard der zaak is dit rapport een stimulans geweest voor verder onderzoek, zodat onze kennis thans groter is dan destijds het geval was.

Het houtduivenonderzoek toonde aan, dat de aantallen waarin deze vogels voorkomen, slechts in zeer beperkte mate wordt beïnvloed door jacht zoals deze tot dusverre werd toegepast. Het resultaat is geweest dat de premie op het schieten van duiven is afgeschaft. Thans hebben wij, sinds wij voor dat doel een ornitholoog konden aanstellen, de mogelijkheid om ook andere schadelijke vogels in het onderzoek te betrekken.

Als een ander resultaat van het werk is te noemen dat een einde is gemaakt aan elk redelijk verzet tegen onze eendenkooien en tegen de nettenvangst van plevieren, voor zover dit verzet berustte op de mening dat de populaties er een nadelige invloed van zouden ondervinden (EYGENRAAM). Uit de aard



Het Itbon werkt mee aan de jaarlijkse tentoonstelling van de geweien der herten die in het afgelopen seizoen zijn geschoten.

der zaak is van het onderzoek niets te verwachten tegen ondeskundige kritiek of wel tegen argumenten die op een emotionele of politieke grondslag berusten.

*

Om meer van de bodemfauna te weten te komen, was reeds in 1941 een onderzoek ingesteld door twee studenten (NOORDAM en VAN DER VAART-DE VLIEGER). Vanaf 1942 is het in een meer permanente vorm gegoten door VAN DER DRIFT. De belangstelling breidde zich uit tot de invloed van schimmels en bacteriën op de omzetting van het strooisel (WENT, WITKAMP, de laatste na zijn vertrek opgevolgd door NAGEL-DE BOOIS) en de invloed van de vochthuishouding op de richting waarin de strooiselomzetting verloopt (MINDERMAN). Toen bepaald onderzoek ver genoeg was gevorderd, zijn er ook de kassen in betrokken, waarbij vooral de ontsmetting een zo belangrijke rol speelt. Bovendien zijn waarnemingen gedaan in boomgaarden, waar bleek dat het ontbreken van regenwormen kan leiden tot het ontstaan van een dikke laag dood, onverteerd gras onder de grasmat (VAN RHEE), terwijl bespuiting met insekticiden grote invloed op de wormenfauna kan hebben (VAN DER DRIFT en BLANKWAARDT).

Het bodembiologisch onderzoek verkeert nog steeds – internationaal – in een beginstadium. De stand van ons inzicht is zojuist in een Nederlands vakblad en in een Engelse publikatie samengevat door VAN DER DRIFT.

In de duinen van de Haagse Duinwaterleiding onder Wassenaar en die van het Provinciaal Waterleidingbedrijf van Noordholland is onderzoek gedaan naar de interactie tussen vegetatie en recreatie en naar problemen die hiermee samenhangen. De onderzoekingen zijn gedaan door een aantal instellingen onder auspiciën van daartoe door het Itbon opgerichte commissies. De resultaten zijn gepubliceerd als rapporten van deze commissies.

Uit de doelstelling van het Itbon is duidelijk af te lezen, dat ook de vegetatie in het onderzoek kan worden betrokken. Bij het onderzoek in de duinen is dit ook geschied, echter niet door het Itbon zelf, maar door het Laboratorium voor Plantensystematiek en -geografie van de Landbouwhogeschool te Wageningen (PROF. DR. H. J. VENEMA). De samenwerking met dit laboratorium is van dien aard, dat geen behoefte is gevoeld aan uitbreiding van onze werkzaamheden in deze richting. Onderzoekingen op vegetatiekundig gebied worden door ons steeds aan het laboratorium van PROF. VENEMA overgedragen. Wij zijn hier dankbaar voor en spreken de hoop uit, dat deze samenwerking in de toekomst zal blijven bestaan.

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Het werkterrein van het Itbon is te groot om door één enkel instituut volledig te worden bewerkt. Ook elders zijn bepaalde delen ervan in behandeling, zij het vanuit een ander gezichtspunt. Om duplicatie te voorkomen en samenwerking te stimuleren, heeft T.N.O. een aantal werkgroepen opgericht. Aan de twee die hiervoor in aanmerking komen, werkt het Itbon intensief mee: de 'Werkgroep Harmonische Bestrijding van Plagen' en de 'Contactcommissie Biologische Bodemverbetering'. De eerste is voornamelijk voor onze afdeling Populatie-dynamica van belang, de tweede voor de afdeling Bodembiologie. Beide zijn van groot nut voor ons onderzoek, mede omdat zij beletten dat wij het te eenzijdig zullen gaan zien.

Ook internationaal zijn er lichamen die min of meer als werk- en discussiegroepen optreden en waaraan wij meewerken. Hiervan is in de eerste plaats te noemen de International Union of Game Biologists, die elke twee jaar bijeenkomt. Op haar vergaderingen wordt hard gewerkt en het nut voor het onderzoek is evident. Van belang is ook de discussiegroep Populatiedynamica van de International Union of Forest Research Organizations, die eveneens om het andere jaar vergadert en stimulerend op ons onderzoek werkt.

Terwijl het uit het bovenstaande duidelijk zal zijn geworden dat de onderzoekingen in hun oorsprong een zekere eenheid vertoonden, blijkt er niet uit of deze ook nog bestaat in het tegenwoordige stadium. In het laatste hoofdstuk van de boven reeds genoemde verhandeling 'Research' wordt gesteld, dat dit het geval is doordat het gehele veldonderzoek er op is gericht om de samenhang in het veld te begrijpen, d.w.z. in het veld zoals dit zich als landschap aan ons voordoet. Of men zich nu richt op een landschapselement als een rij bomen en struiken en de invloed daarvan op het omliggende cultuurland, of wel op de omzetting van organische stof in een landschappelijk gegeven milieu, of wel op het zich handhaven en massaal vermeerderen van een insekt in slechts bepaalde delen van een terrein, enz. enz., de ecologische problemen hebben alle betrekking op het landschap als zodanig.

Deze 'landschapsecologie' – om haar zo te noemen –, waaromheen dus het gehele onderzoek van het Itbon kan worden gegroepeerd, is een schakel tussen twee wetenschappen: biologie en landschapskunde. Het toekomstige werk van ons Instituut zal met deze positie van zijn werkterrein rekening moeten houden.

# II.

## RESEARCH *

**Dr. A. D. Voûte**

*Director of Itbon*

* We are greatly indebted to Mr. J. Brotherhood and his assistants in the Translation Section of the Netherlands Ministry of Foreign Affairs for translating the manuscript into English.

CONTENTS

*Chapter 1*

# INTRODUCTION

Itbon (= Instituut voor Toegepast Biologisch Onderzoek in de Natuur = Institute for Biological Field Research) was founded on 25th September 1940. It was set up by the Central Organization for Applied Scientific Research in the Netherlands (T.N.O.) as a means of providing a firmer financial footing for the work of the two institutions that combined to form Itbon, namely a Committee for Forest Entomology (Comité ter Bestudering en Bestrijding van Insektenplagen in Bossen, founded in 1937) and the 'Hoge Veluwe' Biological Laboratory (1938). It was the severe damage that insect pests had been doing to trees in this country for years that prompted the setting up of the Committee, and the Laboratory was established to enable students of the University of Leyden to carry out ecological field research in the Hoge Veluwe National Park.

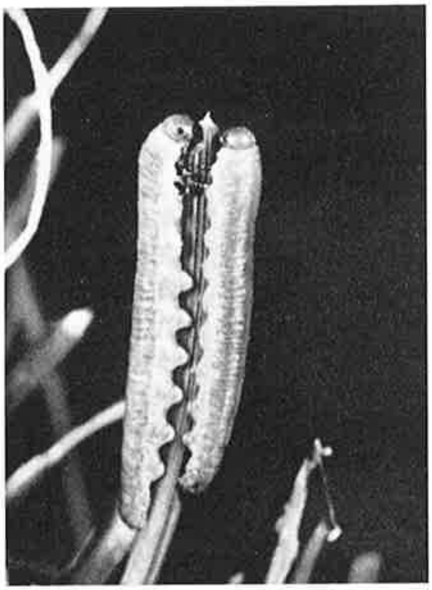
The new Institute was given fairly wide terms of reference, covering the part of research controlled by T.N.O. described as 'applied biological research into forests and other wooded areas, and land not intended for agriculture or horticulture'. The last phrase limited its sphere of action to forests and uncultivated areas. Itbon was officially regarded as a 'research station for uncultivated areas'. In the early days this restriction was not felt to be in any way a hindrance, because virgin countryside was the best place from which to tackle the problems to be investigated, i.e. the ecological control of insect populations, the decomposition of organic matter and the development of soil structure. However, as the research developed it became increasingly necessary to make it embrace problems that were not tied exclusively to the uncultivated areas, mainly because the methods evolved and the knowledge gained promised to be of value to agriculture and horticulture. This was taken into account when, in 1957, new statutes were drawn up and the agricultureal institutes of T.N.O. became part of the Ministry of Agriculture and Fisheries, Itbon becoming a self-governing Institute within the same Ministery. Whilst retaining the original terms of reference, particularly that of the research station for uncultivated areas, the statutes extended them to include 'the improvement of agriculture in the broadest sense of the word', to be achieved by biological research. The idea was to include such subjects as biotic communities in cultivated and natural areas; the ecological control of insect pests; the flora and fauna of uncultivated land, forests and areas earmarked for recreation purposes, and keeping the stock of game at a reasonable level consistent with the proper claims of agriculture.

As a rule, fundamental research is called for if solutions to such problems are to be found. I wish to make it clear that this in no sense runs counter to our duty to carry out 'applied biological research'. In 'pure scientific research' acquiring knowledge is an end in itself, but in 'applied science' the acquisition of knowledge is a means to an end, in this case the control or modification of nature. This concept leaves room for fundamental and non-fundamental research in both pure and applied biological science. If research is undertaken to define the exact position of a genus in the animal kingdom, it must be regarded as fundamental research. But if research is carried out with the object of describing a species, it is certainly not fundamental. Nevertheless, both types are pure science. To return to our own work, if we undertake research into the populating of forests with ants and if we need to understand how queens are adopted in ant colonies, we are concerned with a piece of fundamental research. But if we use this knowledge for an experiment in getting queens adopted by the species in which we are interested, for the purpose of supplying artificially established colonies with queens, the experiment cannot be classed as fundamental research.

*

As already stated, the fact that in 1940 the research work almost exclusively concerned insect pests in forests, was attributable to the large number of pests from which the forests were suffering at the time. The Pine Sawfly *(Diprion pini* L.) received a great deal of attention as did many other species such as the sawflies *Diprion sertifer* and *Cephalcia alpina* and a large number of caterpillars the most important of which was *Ocneria chrysorrhoea* L., the Brown-tail Moth. The object was how to control these pests and to prevent outbreaks. The chemical control work was transferred to the Plant Protection Service before the end of the war, so that from then on Itbon was mainly concerned with the ecological aspects of the matter. This resulted in the launching of a number of research projects, work on which is still continuing, on the habits, distribution, parasitism, etc. of injurious insects. FRANSEN, VOÛTE, BESEMER, ELTON, LUITJES, BLANKWAARDT and DOOM have all worked at these problems, which are described in Chapter 2.

It became apparent soon after the establishment of Itbon, primarily from research into the Pine Sawfly, how scant was our knowledge of the fundamental causes of variations in insect population density. Scant it was, though people like Escherich had clearly indicated one of the lines along which research must develop, and both in Germany (school of Escherich and Zwölfer and that of Schwerdtfeger) and in the Anglo-Saxon and other countries (Thompson, Nicholson, etc.) theories had been developed



Two larvae of Pine Sawfly feeding on one needle.

on regulation of population density. But those theories rested either on observations in the field, usually over short periods only, or exclusively on calculations or theoretical contentions. So as a rule they did not provide a really sound foundation for further investigations so that it was desirable to continue the research. In 1941 a few more or less casual experiments were carried out, the results of which were tested against these theories; it was quite clear that there was a need for some long-term research. So in 1942 a start was made with wide-scale research into population dynamics which has still not been completed. Voûte, Tinbergen, Klomp and Gruys have worked on this research, which is described in Chapter 4.

At first, regulation was only thought of in terms of competition for food and of predation, parasitism and disease. Later, round about 1950, attention began to be focused on the effect that the food-plant might have on the development of phytophagous insects. The possibility that the trees in a wood inhibited the development of the insect population other than by defoliation had not been considered when planning the research into population dynamics. At about the same time, however, our own observations and those of entomologists working in Germany led us to reconsider our opinion. Research work on this subject has been gradually extended. It has been undertaken by VAN DER LINDE and is described in Chapters 4 and 5.

*

As our understanding of the regulation of insect population density increased with the research into population dynamics, it was natural that we should desire to extend our experiments to other groups of animals. In this country certain species of game had been investigated as a side line, usually with an eye to nature conservancy, but in America (LEOPOLD, ERRINGTON), in Germany and in a few places elsewhere it had been developed as a separate branch. The principles underlying population dynamics only entered into the research work sporadically, and the results of the experiments abroad were only partially usable in this country. Consequently, in 1947 Itbon started studying the game indigenous to this country. Begun on the lines of population dynamics, it developed in other directions, too. Damage to agricultural and forest growths and many other problems connected with the management of game were finally included in the research programme. It was in the nature of things that many of the experiments were merely incidental and bore little relation to each other. Now however they are crystallizing into research the object of which is the regulation of the population density of game and are presenting a picture reminiscent of the research into insect pests in 1940 and subsequent years. EYGENRAAM, GLAS, DOUDE VAN TROOSTWIJK and VAN HAAFTEN have worked on these research projects, and associated research on injurious birds is being carried out by STORTENBEKER. The results are described in Chapter 6.

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During the experiments with the Pine Sawfly and a number of other pests the soil fauna were seen to be a very important factor in the control of these pests. Accordingly, back in 1941 the research was extended to include these fauna. As the destruction of the insects in their winter quarters is only a subsidiary function of soil fauna, and fallen leaves and other waste materials are the food on which these fauna subsist, the research was made to include the decompostition of organic matter in the soil and the formation of soil structure. Perusal of literature on the subject revealed that there were a great many gaps in our knowledge. For example, though many research workers were convinced that the fauna would break down the waste matter into stable humus, intitial observations did not support the contention. The decomposition seemed rather to be due to the combined action of fauna, bacteria and fungi, and after 1952 the research was further extended to include bacteria and fungi. The data obtained from the research have proved to be of increasing importance to agriculture and horticulture.

The decomposition of the litter in forests of certain types is still being studied, but since 1954 the soils in greenhouses and orchards have also been examined.

Since 1941 van der Drift, Witkamp, Went, Minderman, van Rhee and Nagel-de Boois have been concerned in this research work. The results are described in Chapter 7.

*

It had already been established both emperically and from literature on the subject, that ants are important as destroyers of harmful insects. Much research had been done on the subject, especially in Germany, but application of the results obtained there did not give entirely satisfactory results in this country and an assignment on the subject was given to students as early as 1940. In 1946 a large research project was launched to find out whether our forests could be populated with red wood-ants. It was clear that a good deal of fundamental research would have to be done if the project was to be a success, and the work is still in progress. A study of other social insects was also undertaken: bumble bees in 1956 and wasps in 1963. It appeared that very little was known about the effect of wasps as predators of injurious insects. Most of these research projects have been and still are being carried out by Elton himself or under his supervision.

The results are described in Chapter 3.

*

The research projects mentioned above have all arisen directly or indirectly from the research into insect pests in forests, but a number of others, too, owe their inception to our work as a research station for uncultivated areas. Chief among them is the research into the effectiveness of windbreaks. For a long time there had been a tendency among farmers in this country to clear most of their arable land of trees and shrubs. But Russian and Danish literature on the subject stated that windbreaks might be beneficial to crops. Accordingly, we placed windbreaks on our research programme in 1941. At first the work was carried out in collaboration with the Royal Netherlands Meteorological Institute, the sole object being to discover how windbreaks affect the climate, but after 1950 their effect on the yield of the agricultural and horticultural land on either side of them was also investigated. The work ended in 1961, the results then being applicable in actual practice. Van der Linde, van Rhee and Shah carried out the research.

Research in the dunes can also be regarded as having sprung from our work as a research station for uncultivated areas. It began in 1948 with an investigation into the effect of vegetation on the quality of water, about which very little was known; a commission was set up to advise dune water companies on control and planting with an eye to recreation facilities and nature conservancy in the dunes.

The results are discussed in Chapter 5.

*

The practice of science may not become self-centred. Our own research always forms part of a larger national plan; that is clear when we see how working parties are being set up in nearly every field of research. The most important ones in Itbon's particular field are the Working Group for Harmonizing the Control of Pests ('Werkgroep Harmonische Bestrijding van Plagen') (Voûte a. de Fluiter, 1961) and the Discussion Group on Experimental Soil Biology ('Contact-commissie Biologische Bodemverbetering') (Minderman, 1962a). The Institute is also very much interested in furthering the aims of international groups, such as the population dynamics discussion group of the International Union of Forest Organizations (I.U.F.R.O.) and the International Union of Game Biologists.

In a Jubilee book like this the emphasis is of necessity on our own research. Work carried out elsewhere is only referred to incidentally. But we would stress that the results achieved have always been due in part to the work of others in so far as it was known to us either from publications or through personal contact.

*Chapter 2*

# FOREST ENTOMOLOGY

## The economical use of insecticides

When Itbon was founded, timber prices were low. Consequently, the profitability of forests was low too, in spite of the very low wage rates then prevailing. Accordingly, the most rigid economy had to be practised. In the circumstances, the insecticides available were far too expensive to be used in forests. In fact people were more or less powerless in the face of the insect pests that were afflicting the forests at the time. It was therefore essential that the cost of insecticides should come down. Fransen displayed great energy and skill in his efforts to bring down the prices of insecticides to such an extent that they could be used to control insect pests in forests. Moreover, in view of the threatened shortage of insecticides after the outbreak of war, he undertook research to find out whether insecticides could be extracted from indigenous plants. But no control method emerged. (s. Fransen in Meded. Com. Bestud. Bestrijd. InsectPlag. Bosschen no. 12, 1942.)

So long as there were large stocks of derris in the country, Fransen (1942b) managed to bring down the kilogramme price of insecticide by reducing the derris content to a concentration that was no longer lethal, not even at the very early stages of development, and adding a very small quantity of pyrethrin. The Pine Sawfly *(Diprion pini* L.) to which the insecticide was applied was stimulated by the pyrethrin so that it came into contact with more insecticide than would otherwise have been the case. In this way, the non-lethal dose of rotenon (derris) became lethal. (Fransen, 1942b.) The carrier originally used was expensive talcum, which was later replaced by much cheaper lime marl (Fransen a. Terpstra, 1946).

Nitro-lime was also used in the research. This proved effective against pine sawflies, provided it was used on sunny days. A shower of rain was often found to nullify the effect. During the war when stocks of derris were getting lower and lower, nitro-lime was practically the only chemical used to keep *Diprion pini* under control. The price of nitro-lime insecticide, too, was brought down considerably by mixing it with cheaper carriers. (Fransen, 1942b.)

As the larvae get older they become less sensitive to derris and nitro-lime. So FRANSEN determined the derris or nitro-lime content of the dusting powders for each particular treatment, thus keeping the cost of the powder low enough for it to be used on a large scale. Hundreds of acres of Scots pine were saved from defoliation in those days by dusting them with powders containing either derris or nitro-lime. (FRANSEN, 1942b.) It should be noted that forests of Scots pine planted in poor soil usually die after defoliation.

FRANSEN (1948a, b, 1951) carried out tests with many other kinds of insecticides, but they were not tried out on any scale, either because they proved too expensive or because they were not obtainable in sufficiently large quantities (FRANSEN a. NIEUWDORP, 1950).

After the war, the modern insecticides DDT and HCH proved cheaper and more effective than the mixtures developed during the war. Moreover, it turned out to be more economical to atomize fluids from aircraft than to use dusting powder. By then the research work had been transferred to the Plant Protection Service at Wageningen, which FRANSEN had joined earlier.

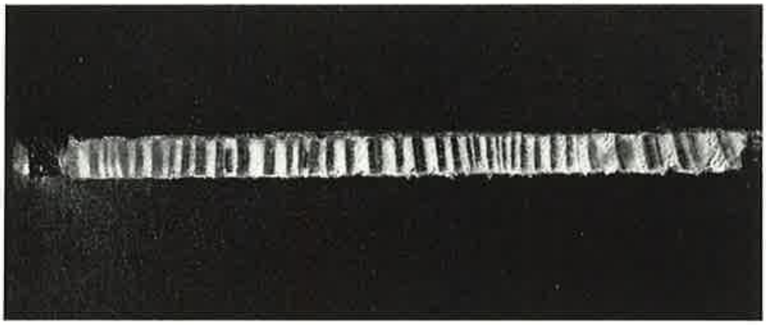
It should be noted that even before the war experiments in dusting infested woods from aircraft had been carried out under FRANSEN's directions. Both military and sports planes were used for the purpose. The results were promising, but the war put an end to the experiments. (FRANSEN, 1942b.)

If optimum use is to be made of modern insecticides, it is essential:

*a.* to know beforehand when infestation with insect pests is likely to occur,

*b.* to know at what percentage of defoliation the application of insecticides would be a paying proposition.

*a.* Much research has been conducted into methods of prediction, expecially in Germany. Is is generally carried out in areas where certain insect pests recur regularly, which is not the case in this country. Methods based on determining the pupa density during the winter are therefore too costly in our case. Accordingly, LUITJES and then DOOM tried a different method, that of counting the fecal pellets. For the time being, research is being confined to the Scots pine. The result of observations made over a large number of years led us to believe that during outbreaks the population density of the insects in question also increased considerably in forests not affected to any great extent. So it was decided in 1954 to count the number of fecal pellets dropped during a certain fixed period both in early and in late summer, in several woods specially selected for the purpose. An endeavour was then made to assess on the basis of the quantity of droppings found what the likelihood was of an outbreak occurring in the same area



The growth of Scots pine is measured. Periods of defoliation result in smaller annual rings.

during the next generation. If the risks are great, a more accurate forecast can be made for the woods in question by the method developed in Germany.

Not once was the population density of one of the potentially injurious insects found to have increased to such an extent as to call for control measures. Nevertheless when *Diprion pini* multiplied substantially in a few other woods, the question arose whether the right woods had been chosen for observations. So in 1962 SCHOTVELD was askeld to study the degree to which various types of forests were predisposed to attack by pest insects. He reached the tentative conclusion that woods between 3rd and 4th site-class quality were the most susceptible to attack by *Diprion pini*. This appeared to conflict with LÜDGE's observations, who had reached the conclusion that the lowest site-class qualities were affected the most. However, on visiting LÜDGE's experimental forests near Heidelberg we saw that the lowest site-class quality there is comparable with our 3rd site-class quality. The investigations have shown that it will be necessary to reconsider the criteria governing the choice of forests for the experiments.

*b.* In sylviculture it is not only important to know when an outbreak may be expected and what percentage of the leaves or needles may be destroyed; some information should also be available on the question as to what minimum percentage of defoliation would warrant the taking of control measures. Before that can be discovered it is necessary to know what effect

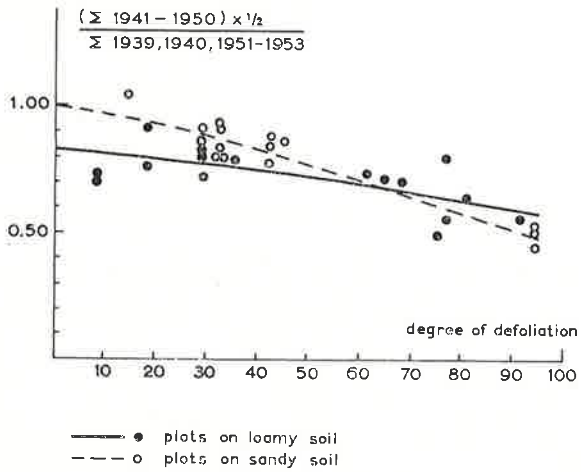



Fig. 1 (LUITJES, 1958b). – The relation between the relative increment and the degree of defoliation in Japanese larch.

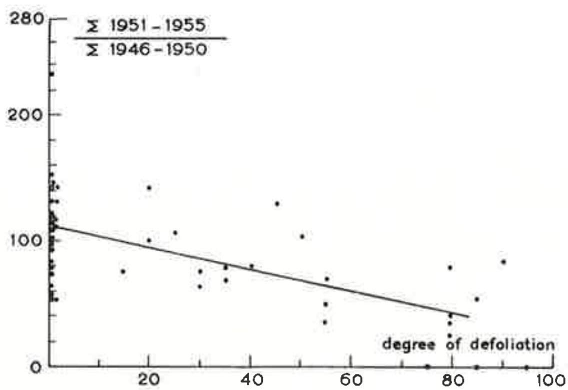



Fig. 2 (LUITJES, 1958b). – The relation between the relative increment and the degree of defoliation in Scots pine.

different percentages of defoliation have on the growth and death rates of trees and to what extent the cost of control is offset by the greater yield of timber.

As early as 1940 FRANSEN (1947) made some tentative tests. He removed the leaves from two-year-old poplar cuttings and saw that the growth rate was reduced by about 50%. Later on, LUITJES (1958b) made a thorough investigation of the matter. As can be seen in Figs. 1 and 2, he found that for the Japanese larch *(Larix leptoleptis* MURR.) and Scots pine the loss of growth was proportionate to the percentage of defoliation. He also found that defoliation of Scots pine resulted in a higher death rate. That holds good especially for inferior soils. We have seen entire forests die off under such circumstances. LUITJES reckoned that expenditure on chemical control became justified from the point at which defoliation amounted to between 5% and 10%; he based his calculations on the cost of control and the current value of timber. In view of the higher wages and the fall in timber prices, different standards will have to be adopted in future when determining the degree of defoliation at which control would be worth the expense. Moreover, SCHOTVELD's research has raised another point that LUITJES was unable to deal with during his investigations. If a tree should, under certain circumstances, recover from its loss of growth, will it ultimately attain the same stature as trees that were not affected? If so, the damage due to defoliation might be much less in certain cases than that arrived at by LUITJES. We hope to be able to investigate the matter one day.

## PEST INSECTS

A special organization, called the Forest Insect Survey, was set up as early as 1938 for collecting data on outbreaks causing more or less serious damage to forests. The data are published annually (LUITJES a. VOÛTE, 1956). They will become when conducting research into the ecology of various pest insects, which has already produced good results on several occasions, e.g. with *Evetria buoliana* (VOÛTE a. WALENKAMP, 1946d) and *Euproctis chrysorrhoea* (VOÛTE a. VAN DER LINDE, 1963).

A fairly large variety of forest insects did such great damage at certain times during the last 25 years that more thorough investigation became imperative. The species involved were:

### *Diprion pini L. and Gilpinia pallida Klug (pine sawflies)*

Research on pine sawflies was conducted by FRANSEN, BESEMER, VOÛTE, ELTON, LUITJES and DOOM.

A clear relationship between these pests and the location of the woods was established during the outbreaks that occurred between 1937 and 1944. The outbreaks developed among pine wildlings in and around the shifting sands. The surrounding woods were attacked from there. Such outbreaks did not last for more than a year. The short period during which the woods were affected was explained by the presence of two kinds of mice *(Apodemus silvaticus* L. and *Clethrionomys glareolus* SCHR.) in the woods, which were not found among the pine wildlings. In winter nearly 100% of the cocoons often fell victim to their predation. Predation by red ants has on occasion caused a high death rate among the almost mature larvae, especially in wooded areas. In the areas of the pine wildlings it was an egg parasite, the *Achrysocharella ruforum* KRAUSSE, which put an end to the outbreak in the third or fourth year. A parasitization percentage of about 35% generally meant that parasitization in the next generation would rise to 100%. (BESEMER, 1942; VOÛTE, 1944/45b.)

In the years 1950 and 1951 the outbreaks took on a different appearance. They occurred more autochtonously in the forests themselves, leaving the pine wildling areas more or less untouched (ELTON, 1951a; ELTON a.o., 1955). Moreover, *Gilpinia pallida* was often found side by side with *D. pini.* Slight damage by *G. pallida* during the initial period might have been overlooked. (DOOM, 1963b.)

During the latter outbreak the mortality as a result of predation by mice during the winter was considerably lower than in the period between 1937 and 1944 mentioned earlier. The population densities of mice were not determined, but the general impression was that the woods were comparatively thinly populated with mice in the period in question.

The last outbreak coincided with a period in which the growth of non-affected forests was also below normal (see Fig. 3). The condition of the

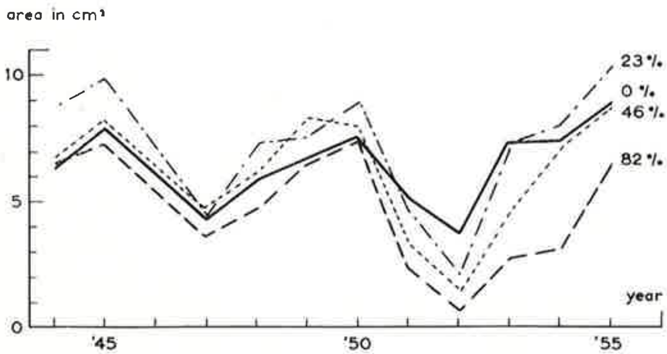



Fig. 3 (LUITJES, 1958b). – Mean area of the annual rings at breast height in four classes of defoliation in Scots pine.

forests was probably a contributory factor. (LUITJES, 1958b.) This is borne out by the fact that at the early stages of outbreaks in one and the same wood some trees were entirely free from larvae while others were already completely defoliated.

It is important to note that for practical purposes:

1. If there is egg parasitization of about 35% there is no need to control the next generation.
2. The presence of mice increases the resistance of woods. It is therefore necessary to provide cover for mice by cultivating undergrowth or by branch-dressing.

*Neodiprion sertifer Geoffr. (Red Pine Sawfly)*

HEIN'S (1956) research on the Red Pine Sawfly has taught us that the condition of the woods largely determines the extent to which this sawfly can deposit its eggs on pine needles. If the moisture content of the needles is either low or very high, no eggs are deposited (see Fig. 4). The shape and the size of the needles are also important.

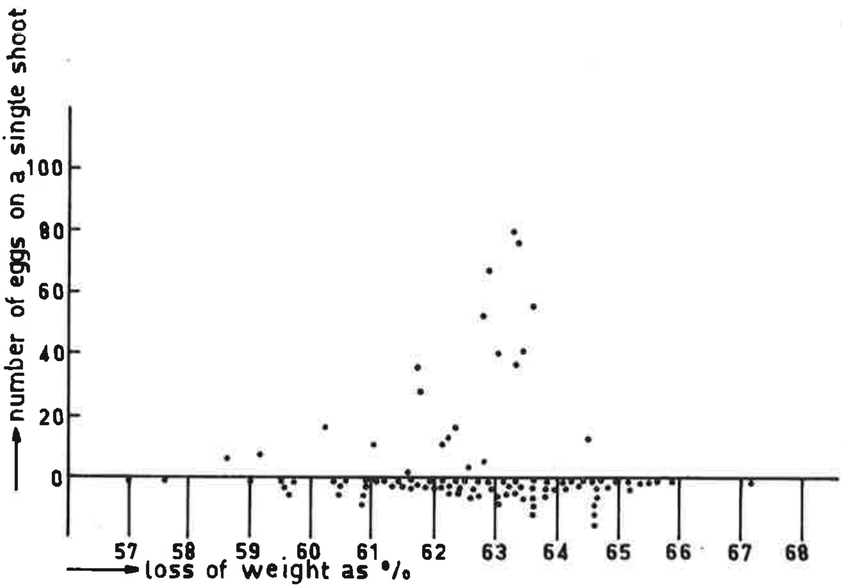



Fig. 4 (HEIN, 1956). – Relation between the number of eggs of *Diprion sertifer* and the humidity of the shoot.

*Cephalcia alpina Klug (a larch sawfly)*

First MINDERMAN and then LUITJES conducted research into *Cephalcia alpina*. The attack occurred in the Japanese larch and it was most persistent. It lasted from 1941 until 1950 and it manifested itself almost exclusively in the province of Drenthe. Their research taught us that wooded areas planted in 1929 were the first to be attacked, even if first affected in entirely different years. Afterwards other larch woods were affected, or the original infestation spread to other areas. (LUITJES a. MINDERMAN, 1959.) It was noticed that infestation occurred in periods when the growth of larches was exceptionally small, also in woods not affected (see Fig. 5). It very much looks as if the condition of the woods was a contributory cause (LUITJES, 1958b).

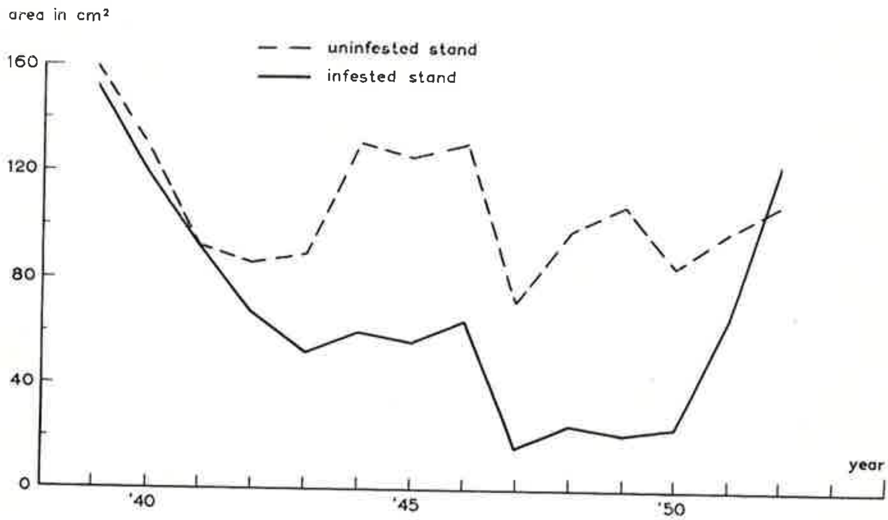



Fig. 5 (LUITJES, 1958b). – Mean area of the annual rings at breast height in larch woods infested and non-infested by *Cephalcia*.

*Various species of sawflies on larches and Norway spruce*

Our larch forests were, especially in the years 1940–1945, seriously affected by defoliation by a number of sawfly species, such as *Cephalcia alpina*, *Pristiphora laricis* HTG, *P. erichsonii* and *P. wesmaelie* TISCHB. (VOÛTE a. PELSMA, 1942.) The Norway spruce was damaged by the larvae of *Pristiphora abietina* CHR. and *Pachynematus scutellatus* HTG.

FRANSEN, VOÛTE and PELSMA have in smaller or larger measure included all these species in their research.

An outbreak by *P. erichsonii* was ended by wood mice devouring almost all the larvae during the winter. It was noticed, though, that the cocoons on the slopes of drainage ditches were left alone, so that the outbreak was sustained from there. When for that reason the ditches were filled in, the sawflies disappeared almost completely. In this case, the research conducted by our Institute resulted in effective biological control. (VOÛTE, 1964b.)

*Pristiphora abietina* did not attack early budding Norway spruce. Trees budding very late, on the other hand, were affected, but the larvae did not mature fully (VOÛTE, 1944/45c). Norway spruce that came into bud normally were often badly affected.

An outbreak by *Pachynematus scutellatus* was nipped in the bud by predatory *Formica polyctena* FOERST. The ants congregated in large numbers under the trees from which the larvae of *Pachynematus* allowed themselves to drop prior to wintering. (VOÛTE, 1964b.) Examination of the litter left no doubt as to the effectiveness of the predation. Only a few dug-in larvae were encountered; they may have been the first to drop before the ants had started to gather under the trees.

FRANSEN (1949, 1948a, 1942b) carried out research on the control of these sawflies; he showed that most of the species could be exterminated with the insecticides then available. Nitro-lime, however, proved unsuitable against *Pristiphora abietina* because it damaged Norway spruce.

*Evetria buoliana Schiff. (Pine Shoot Moth)*

VOÛTE and WALENKAMP (1946d) studied the habits of the Pine Shoot Moth. They found that if the month of July was dry it was very often followed by 'posthorn'-shoot damage in the next year, which is characteristic of this pest. The cause was traced to the fact that the newly hedged caterpillars found in July can only bore into the needles of Scots pine if the tree has suffered from drought. The greater number of caterpillars after the dry month would produce a larger number of 'posthorns' in the following year (see Fig. 6).

It appeared that serious damage by *Brachyderes incanus* L. was invariably followed an outbreak of *E. buoliana*, even in years when July had not been a dry month. This beetle apparently causes the tree to dry up suficiently.

It is important to note that in practice:

1. steps should be taken to get the young saplings to close up quickly to prevent infestation by *Brachyderes;*
2. the soil should have its optimum water-retaining capacity. Accordingly, it is advisable not to dig too deep if doing so would destroy the structure of the soil either permanantly of for a long time.

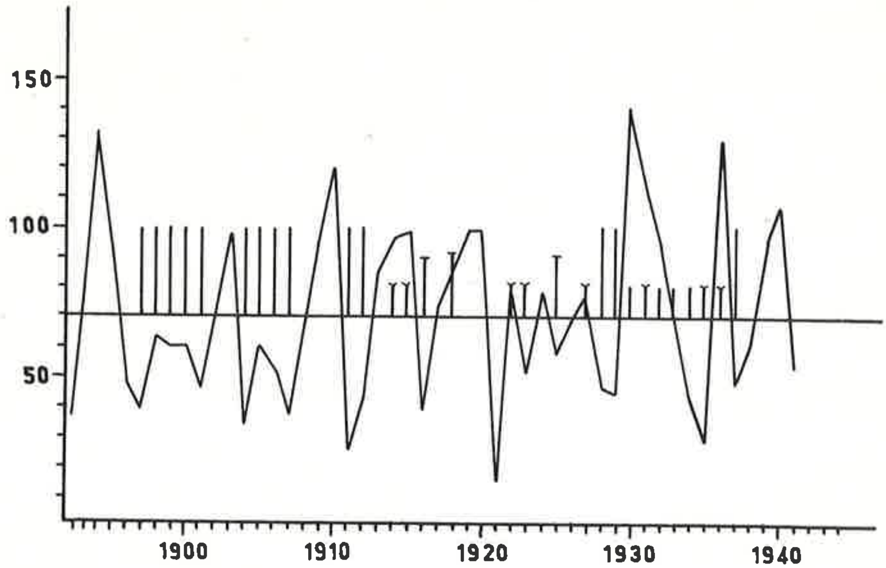



Fig. 6 (Voûte, 1946d). – Outbreaks of *Evetria buoliana* in relation to the rainfall in the month of July. Mean rainfall ± 70 mm. The curve indicates the rainfall in July in the different years. Different types of vertical lines indicate different types of outbreak:

= major general outbreaks.

= minor but general outbreaks.

= local outbreaks in connection with outbreak of *Brachyderes*.

= local outbreak without any connection with *Brachyderes*.

*Coleophora laricella Hb. (Larch Case-Bearer)*

Infestation by the Larch Case-Bearer was studied by Fransen, Voûte and ter Pelkwijk. It was found that the condition of the forests was largely determinative of infestation. When the needles turn yellowish late in autumn, the majority of the larvae attach themselves to the needles for the winter with gossamer; they then drop to the ground, needle and all, and are destroyed. If the needles turn yellow early, the grubs are compelled to attach themselves to the twigs where they can last through the winter in their cases. Consequently, larches suffered less from the pest on good soil than on bad. (VOÛTE a. TER PELKWIJK, 1948.)

It was shown that the Larch Case-Bearer could be effectively controlled with insecticides, provided they were applied at the right time (FRANSEN, 1948b).

Accordingly, larches should not be planted in unsuitable soil.

*Euproctis chrysorrhoea L. (Brown-tail Moth)*

Research into the Brown-tail Moth previously conducted by FRANSEN and VOÛTE is being continued by VAN DER LINDE. In the Netherlands this moth is found mostly in trees and shrubs. Wintering under damp conditions results in a high mortality rate among the young caterpillars; places exposed to the wind are favourable for them (FRANSEN, 1942b).

The condition of the trees largely determines whether infestation is likely to occur. This is the conclusion reached from the following data:

1. The host plants become vulnerable to infestation in a certain order, viz. first sea buckthorn, then hawthorn, pedunculate oak, poplar, American oak, etc. (VOÛTE a. VAN DER LINDE, 1963).

Oak affected by Brown-tail Moth; see text.

2. The caterpillars sometimes leave their host plants in periods when the latter are unsuitable for them. Near Arnhem they left the oaks, but they did well on hawthorn. At the same time they came to full maturity on oaks in the province of Brabant and 15 kilometres to the north of Arnhem they also abandoned hawthorn.
3. It was noticed that in periods when there was no real infestation certain oaks that were not doing well were badly affected (see photo).

Treating these oaks with insecticides at times when there is no infestation might prove effective. The method has not been tested yet.

*Lymantria dispar L. (Gipsy Moth)*

Research on the Gipsy Moth is being conducted by VAN DER LINDE. The distribution of the caterpillars is somewhat similar to that of the Brown-tail Moth. It is also found in trees where the caterpillars of that moth are found in large numbers in periods when there is no outbreak.

An outbreak of this pest in a larch wood was studied. It was found that the density of the caterpillars decreased in a north-easterly direction. In the south-west the density was so great that the trees were defoliated before the caterpillars had grown to maturity. The caterpillars there either died of starvation at an early age or migrated. Around this area that was completely defoliated in the early stages there was a ring of trees that had been almost or only just defoliated and the caterpillars actually did mature there, but they were nearly all diseased. They hung limply from the twigs and their bodies were filled with a dark-coloured fluid. A little farther away the wood was not defoliated. The caterpillars had reached the pupal stage. Few if any were diseased, but predation of the pupae by birds was great.

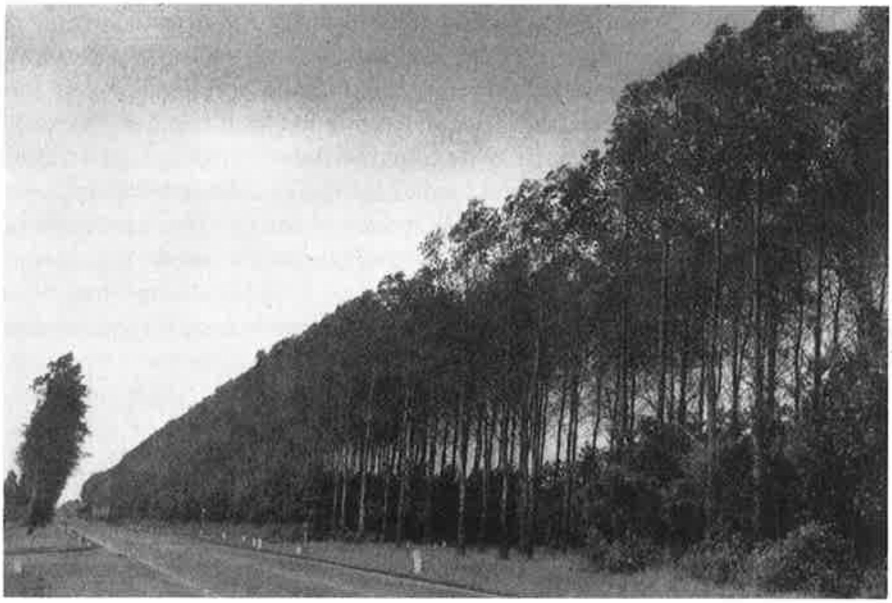
*Stilpnotia salicis L. (Satin Moth)*

FRANSEN conducted research into the Satin Moth around 1940. It was later continued by DOOM. As in the case of *Euproctis chrysorrhoea*, the caterpillars maintain themselves on a few trees during a period when they are hardly to be found anywhere else. The trees are also seen to grow poorly (see photo). Some trees seem to be particularly susceptible to this pest; the condition of the trees in question probably has something to do with it.

For practical purposes the same remarks apply as for *E. chrysorrhoea.*

*Cossus cossus L. (Poplar Goat Moth)*

Poplar Goat Moth, a polyphage which lives on deciduous trees, has been studied by BLANKWAARDT and others (1954). Investigations have shown that



Poplar affected by Satin Moth; see text.

caterpillars that had only just emerged could only bore into trunks in places where the bark had been damaged. Old caterpillars, however, could also attack sound trees. Tunnels made by the older caterpillars were used by the younger ones as avenues of attack. A first attack on an area may therefore be expected to occur in a trunk that has been damaged in some way or another. Young caterpillars will attack such trees again and again. Under certain circumstances, which have not been further investigated, old *Cossus* caterpillars sometimes abandon their old tunnels. If they bore into other trunks, the infestation may be permanently transferred to those trees. If an infested tree is cut down, the caterpillars will leave it after a while and attack other trees in the neighbourhood, with disastrous effects.

*Hylobius abietis L. (Pine Weevil)*

ELTON and others (1964) have conducted research into the conditions under which stumps are affected by the Pine Weevil. The development from egg to imago took from 14 to 18 months. A generation appeared to live for two years. Whether the stumps were in forests or in felled areas did not appear to make any difference to the quantity of beetles that developed in them. The barking of stumps, formerly regularly resorted to in this country in an attempt to control infestation, proved useless. The number of beetles that developed in barked stumps was certainly not smaller than that in unbarked stumps. It seems that the number of mature beetles is determined by the quantity of food available to the larvae, at all events outside forests. This would imply that competition for food among the larvae regulates the population density. Steps were also taken to discover what other kinds of insects were to be found in the stumps during and after the feeding period of the *Hylobius* larvae. Excepting *Myelophilus piniperda* and *Hylastes ater* PAYK., they were all species of little or no importance to forestry. Some of them may compete with *Hylobius* for food.

As a result of this research, the practice of barking stumps has been stopped. The tentative method of controlling infestation is rather to immerse the seedlings in a DDT solution or spray them after they have been put into the ground. Another effective method of control is to allow two years to elapse between the felling of trees and the planting of new seedlings. This waiting period might be shortened if it were combined with immersion of the seedlings in a DDT solution.

*Pissodes piniphilus Hbst.*

VOÛTE (1940b, 1964b) has studied the weevil *Pissodes piniphilus*, which occasionally tends to reach outbreak level. He found that outside mass-development periods about five per cent of the larvae and pupae were destroyed by woodpeckers. At the initial stages of mass-multiplication, when a few sound trees are fed upon and killed, the mortality rate rises to over 95 per cent. Under the conditions prevailing in the Netherlands outbreaks never continued after that.

*Cryptorrhynchus lapathi L. (Willow Weevil)*

A poplar damaged by larvae of *Cryptorrchynchus.*

Since the Willow Weevil is known to spread bacterial canker of willows and poplars, DOOM studied the habits of this beetle to discover the best time to control it. It was found that during its two-year development *C. lapathi* winters not only as a beetle but also as a larva. Wintering of eggs has not been observed. In this country, beetles are mainly encountered in even years and larvae in odd years. Since according to literature, insecticides are more effective against larvae than against weevils, the month of May in odd years is the best time for chemical control. (DOOM, 1965a.)

*Dendroctonus micans Kug. (European Spruce Beetle)*

It was ELTON (1950a) who made a study of the European Spruce Beetle. In the Netherlands it attacks the sitka spruce in particular. Nearly all sitkas that have reached an age of 35 years fall victim to this beetle sooner or later. *Picea orientalis* is also very susceptible. Much less so are *Picea Abies*, a few other kinds of spruce *(P. Omorica, P. Glauca)* and Scots pine. No connection could be established with the prevalence of root fungus.

*Hylesinus fraxini Panz. (Ash Bark Beetle)*

After studying the Ash Bark Beetle, BLANKWAARDT (1956) concluded that it did not transmit ash canker. Cankerous bark growths could be induced in sound trees by the wintering tunnels of the beetles, but they did not harm the trees themselves.

It appears that the beetles can winter twice.

Since these beetles are of a highly secondary character, damage was seen to have occurred mainly where languishing trees or branches such as loppings and prunings were encountered and at places where trunks were being sawn up.

*Myelophilus piniperda L. (Pine Shoot Beetle)*

The Pine Shoot Beetle was studied by FRANSEN, VAN DER LINDE and VOÛTE.

The date from which this beetle may be encountered in the field has been determined from a great number of phenomenological observations (FRANSEN, 1941). This date is important since it determines the moment at which trapping-logs must be laid to control the pest. It appeared that under favourable weather conditions flights of this beetle may occur as early as February. Larvae have been developed at various temperatures in the laboratory; the experiments showed that the rate of development is greatly affected by the temperature. In fact, the beetles may be expected in the open sooner in a warm year than when the weather is cold. Research showed that young beetles do not emerge until 1st June, so the removal or barking of felled trees before 15th May, which is the date laid down for it by law, does protect woods against the maturation feeding of the young beetles. It was also found that egg-laying beetles cannot be expected to fly after 1st August. (VOÛTE, 1942.)

The young beetles that tunnel into the shoots of sound Scots pine do not as a rule spread beyond a radius of about 25 metres. However, if there is no Scots pine in the neighbourhood, they may cover great distances, more than a kilometre in fact. Consequently, logs stacked some distance from an infested wood may attract flying beetles and so be the cause of serious damage

Mother gallery and larval burrows of the Pine Shoot Beetle. The bark has been cut away.

to Scots pine surrounding the stack. One year old beetles prefer freshly felled logs for their oviposition to languishing standing trees. This has been taken advantage of to keep the beetles away from trees that were temporarily languishing. The beetles cannot tunnel into perfectly sound trees, so they cannot lay any eggs in forests in which all the trees are sound. There is only one generation a year. In autumn the ovaries of the beetles are not yet developed. (VAN DER LINDE, 1948a.) Nevertheless, once two beetles were found in October that had made a mother gallery in which they had laid eggs, but the hatch perished. It was impossible to discover whether they were very late beetles of the previous year or beetles of the current year that had matured abnormally early.

Foresters mistakenly attributed to *Myelophilus* the exceedingly high mortality rate among Austrian and other pines in the dunes in 1963. The fact was that the beetles found plenty of suitable breeding places in trees that were languishing to such an extent for other reasons that there was no hope whatsoever of their recovering (VOÛTE, 1963a).

For practical purposes it is important to note that the beetles only reproduce in languishing trees and that they have a preference for felled trunks. So it is only in forests that are temporarily languishing for some reason or other that there is any point in laying trapping-logs. This will often keep the beetles away the languishing trees.

A drawback, though, is that trapping-logs must be present in the forests right from February to August and that it must constantly be barked or removed before the young beetles emerge.

*Saperda carcharias L.*

Roadside poplars infested with *Saperda carcharias* are chiefly met with near houses (see Fig. 7). No explanation for this phenomenon has been found yet. The habits of this insect are still being observed, because too little is known about them. The research is being carried out by DOOM.

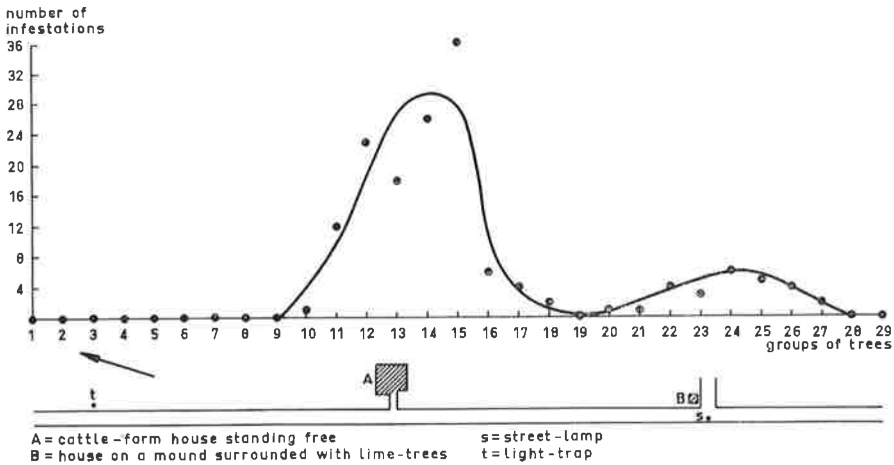



Fig. 7 (DOOM, s. Annual Report 1963). – Infestation of poplars, planted along a road.

*Polyphylla fullo L.*

The beetle *Polyphylla fullo* was studied in the dunes by BLANKWAARDT (1965).

He noticed that the larvae preferred sand with a humidity corresponding to that at a certain depth in the dunes with sparse vegetation during dry periods. Dunes with dense vegetation such as dune woods are too dry for the larvae during a dry period; the grubs cannot live in them and they find it difficult to move. A list of host plants was compiled in the order of preference. The larvae were seen to have a great preference for beach grass; it is a plant that is prolific in areas that are particularly suitable for the larvae. It is hardly ever damaged. But woody plants planted to prevent the dune sand from shifting are damaged.

A $^1/_4$% solution of lindane proved effective against the larvae.

In practice it is important to remember that:

1. young seedlings can be protected for at least two years by treating them with lindane,
2. planting the seedlings close to each other renders the soil less suitable for the larvae.

### The resistance of forests to outbreaks of insect pests

The question as to whether woods can build up a greater resistance to insect pests has been approached from various angles.

In the first place, the results of observations made on the spot during outbreaks have been closely examined and co-ordinated. One of the conclusions reached was that mixed forests, and forests with fairly dense undergrowth are generally less seriously affected than mono-forests. Scots-pine forests with plenty of undergrowth, for instance, are seldom found to be infested with *Diprion pini*. However, it is extremely doubtful whether mixing has any effect for example on resistance to *Tortrix viridana* L., a moth that in this country regularly feeds on and often completely defoliates oak trees. Investigations have also been carried out with a view to discovering whether it would be possible to create favourable conditions for predators so as to minimize the risk of damage by injurious insects. It is stated in this chapter that outbreaks of *Pristiphora erichsonii* can be effectively controlled by encouraging or protecting mice; similar measures are also expected to be effective in controlling other sawflies, such as *Diprion pini*.

A special, thorough study was made of the 'planting' of ants in wooded areas. The subject is dealt with in the chapter on social insects.

The studies described in this chapter of a large number of insects that do damage to trees, showed that the likelihood of an outbreak occurring depended very largely on the condition of the trees. Encouraged bij the favourable results obtained in Munich, and later in Göttingen and elsewhere by manuring the forests and thus considerably raising the mortality rate among leaf-eating insects, we are now conducting research into the effect of manuring plots planted with Scots pine. The work is being carried out by Gruys.

In two woods aged eight and thirty-five years respectively, some areas have been treated experimentally with nitrogen, phosphorous and potash, both separately and in various combinations, viz. NPK, N, NK, NP, P, PK and K. The condition of injurious insects in those plots was compared with that in control plots. After the first year, a significantly smaller number

| Manuring | Number of healthy cocoons per sq. mtr | | | Number of dead cocoons per sq. mtr | | |
|---|---|---|---|---|---|---|
| | Plot 1 | Plot 2 | Mean | Plot 1 | Plot 2 | Mean |
| NPK | 4 | 3 | 3.5 | 3 | 3 | 3.0 |
| N | 3 | 5 | 4.0 | 0 | 8 | 4.0 |
| NK | 2 | 4 | 3.0 | 4 | 2 | 3.0 |
| NP | 1 | 4 | 2.5 | 9 | 5 | 7.0 |
| P | 4 | 4 | 4.0 | 5 | 5 | 5.0 |
| PK | 13 | 14 | 13.5 | 7 | 5 | 6.0 |
| K | 3 | 10 | 6.5 | 6 | 6 | 6.0 |
| O | 12 | 8 | 10.0 | 8 | 6 | 7.0 |

of healthy cocoons of *Diprion pini* was found in plots that had been manured with N, viz. 2.2 per square metre in the N areas as against 5.7 in areas without N. Strangely enough, there was no difference between the respective numbers of dead cocoons (see Table). After the second year of fertilizing, the number of *Diprion pini* cocoons was extremely low throughout the woods, so that it was difficult to interpret the values found. What was noticed, however, was that, taking the number of cocoons per square metre as the criterion, there was a clear relationship between N and P in that in areas without P fertilizers the cocoon density was great if no N fertilizers had been used, but slight whenever they had been used. On the other hand, if P fertilizers had been employed, the influence of N fertilizers was just the reverse. It was impossible to explain this phenomenon.

On the other hand, many pupae of *Bupalus piniarius* were found in that second year. The number of pupae per square metre was far greater in N plots than in areas where N had not been used. Moreover, the pupae in N areas were heavier. This conflicts with what is stated in German publications on the subject, namely that the mortality rate of the majority of forest insects, including the *Bupalus*, rises and the condition of the larvae deteriorates whenever fertilizers are used. An explanation had not yet been found.

After consulting the literature on the subject and having regard to the results obtained from experimental research, some papers were written for Dutch foresters (VOÛTE, 1964a) and forest entomologists (VOÛTE, 1964b), in which the view was expressed that the resistance of our forests could be improved by:

*a.* improving the condition of the trees (by applying fertilizers);

*b.* mixed planting or the planting of undergrowth, provided that this in itself is not harmful to the trees;

*c.* increasing the population of predators (wild boar, mice, birds, ants, etc.) and parasites. (VOÛTE, 1951c.)

Shortly after our Institute was founded, it was evident from both field and laboratory research that the population-dynamics basis of our work was utterly inadequate. So that part of the work was extended. The results are discussed in a separate chapter.

Research also taught us that there are many other soil fauna besides mice that can act as important predators of our injurious insects. This led to research being conducted into soil organisms. This work, too, is discussed in a separate chapter.

### PROSPECTS OF THE WORK ON FOREST ENTOMOLOGY

The reasons for which forests in this country are important are continually changing. Before the war there were woods for recreation and forests for the production of timber, and wooded areas primarily regarded as hunting fields. In the immediate post-war years the emphasis was on timber production. The general opinion was that timber forests would always be profitable provided they were well managed, in other words, that a low but reasonable return on the money invested in them was assured. It was probably the very same belief that induced people in the previous century and early in the present one to afforest large areas of our moorland with mono-specific cultures of Scots pine. Later, however, the view gained ground that woods should be more mixed and especially that they should also be planted with brushwood. Forestry became increasingly rationalized especially after the war, so that more and more of the work was mechanized. This again led to a preference for mono-specific forests; undergrowth was regarded as a hindrance to mechanized operations. Moreover, production of timber had to be increased. It was hoped that the profitability of forests would be raised by turning them into mono-specific forests or at any rate that it would minimize the effect of sharply rising wages.

For several years now we have been witnessing a different trend. Mechanization and the increased production of timber cannot keep pace with rising costs, especially since timber prices do not evince any tendency to rise. On the contrary, the mines are buying much less timber than they used to, with the result that the prices of certain qualities are falling; firewood does not attract many buyers and more and more substitutes for wood are coming on to the market. Consequently, the profitability of timber forests continues to decline. Another factor is that the value of land is going up and, since it is becoming a scarce commodity in our densely populated country, it will continue to rise indefinitely. A side effect of this continual rise in prices is an increase in property tax. So, taking all the circumstances into account, it is understandable that even the best managed private timber estates are losing money. More than ever before, the tendency will be deliberately to put forests to multifarious uses. It has long been realized that, although forests may not be profitable, they cannot be dispensed with. People are also fully aware of the fact that forests can only be maintained if they are well managed. The dual function of forests as recreational areas and sources of timber will no doubt be more fully recognized than it is at present. The management policy will be viewed against the following background;

1. low initial cost of afforestation and upkeep;
2. the greatest possible production;
3. continuity of production;
4. suitability of forests for recreational and other communal purposes.

All this will undoubtedly affect forest management and forest entomology, too. The production of timber will of course continue to be an important function of forests, but it will no longer be their primary function. The question 'How can I enhance the recreational value of my forest?' is attended by a second question 'How can I keep down the financial loss?'.

It should be realized that all kinds of young forests in general and young pine woods in particular should also be planned so that they will be suitable for recreational purposes as well. Young pine woods are often very gloomy and therefore less attractive. Older woods, on the other hand, are of great recreational value. It is hoped that the rotation period will be lengthened in forests the primary function of which is recreational. The pleasure of walking in woods is greatly enhanced by the presence of wildlife of some sort, especially of birds and the larger mammals. The best way to foster wildlife is to mix the vegetation as much as possible. The reader should peruse TINBERGEN's article (1949) on woods and forest birds; he will then see how very greatly the bird population can be increased by planting a great variety of trees in a wood. Old park-like landscapes interspersed with wooded areas of not too large a size are actually the richest in birds and large mammals and the most attractive to people seeking recreation.

Of course it can never be the object of forestry to convert the entire afforestation area in a country into parkland. We can imagine parkland developing in regions where woods border on moorland or dunes. It is also not unlikely that there will be a tendency to surround other large wooded areas with grounds of a more park-like nature. Open woods will then gradually merge into more thickly wooded areas of alternatively older and younger woods. If such woods are planted in good quality soil, they will do well on the whole and the trees will be sound. But from the point of view of forest entomology not only woods on good soil, but also those on poorer soils may be expected to acquire greater resistance to attack pest insects.

Consequently, it will become less and less essential for the forest entomologist to employ insecticides to control insect pests. Moreover, as stated in this chapter, conditions have changed since 1958, when according to LUITJES defolation of between 5% and 10% was sufficient to justify the application of insecticides to control the attack. Since then the cost of both insect control and the upkeep and maintenance of woods have risen to such an extent that control only becomes worth while at a much higher degree of defoliation. The same thing is even more true of an extension of the rotation period. The longer the interval between the application of insecticides and the felling of the timber, the greater the loss in timber that may be accepted; in other words, the greater the defoliation that can be tolerated before the application of insecticides becomes profitable.

However, there is also a limit to the degree of defoliation beyond which the taking of steps to control it cannot be deferred. Woods which on account of defolation languish for years or even die are useless for recreational purposes. Insecticides would have to be applied before things come to such a pass.

It will generally be easier to prevent the widespread incidence of insect pests in the kinds of forests described above (provided they are well managed) than of forests primarily intended for the production of timber. Since variety is the aim, it is better to take advantage of slight differences in soil conditions when choosing different types of trees. There is no need to be afraid of undergrowth, for that will make its appearance anyway as the forests get older. It is easier to create mixed woods if they are intended especially for recreation, and they can be laid out more naturally than forests primarily intended for timber production; mixed forests are more likely to produce healthy trees. The fact that the trees need no longer be planted so close together is also conducive to healthy growth, because they are no longer forced to produce tall, bare trunks.

We also believe that modern forestry will make excessive rationalization in recreational woods a thing of the past. Old, hollow trees can be left standing so that insect-eaters, such as bats and birds, can hold their own. This will not only affect the part of a wood specially planned for recreation but also other parts nearby where timber production is the chief objective.

However, leaving too many old and overripe trees standing will increase the risk of infestation. But the risk can largely be overcome by selecting the right mixture of trees.

Though the greater ease with which outbreaks by insect pests could be checked with insecticides at first resulted in less and less interest being taken in measures designed to increase the resistance of modern timber forests, the inclusion of the provision of recreational facilities among the objectives of forestry has once again brought the matter of resistance to insects to the fore, but without dismissing chemical control as unimportant. If insecticides are used, however, care should be taken that the side effects are reduced to a minimum; in other words, the risk of harming animal life the woods themselves or the small streams flowing through the woods must be avoided or reduced as much as possible, for they are so important from a recreational point of view. It is therefore of primary importance for the future that a happy balance be struck between measures to increase the resistance of woods and measures to exterminate insects. This type of control is called 'harmonious control' (VOÛTE, 1958a). Even more so than in agriculture and horticulture the value of the application of insecticides should be carefully weighed against their possible injurious side effects. Research to discover how to achieve harmonious control of insect pests in forestry should be conducted independently, and as in the past, the research carried out for the benefit of agriculture and horticulture will very likely take its cue from the research conducted in respect of forests.

In view of the fact that in future there will be much less occasion to plant large tracts of mono-specific woods, better opportunities are likely to occur for planning small areas in such a manner that the trees can grow in places where optimum conditions obtain and where they will be least liable to damage by injurious insects. Forests can be planned in accordance with the natural structure of the landscape. The forest entomology of the future will largely be governed by the principles of landscape ecology described in the last chapter.

*Chapter 3*

# SOCIAL INSECTS

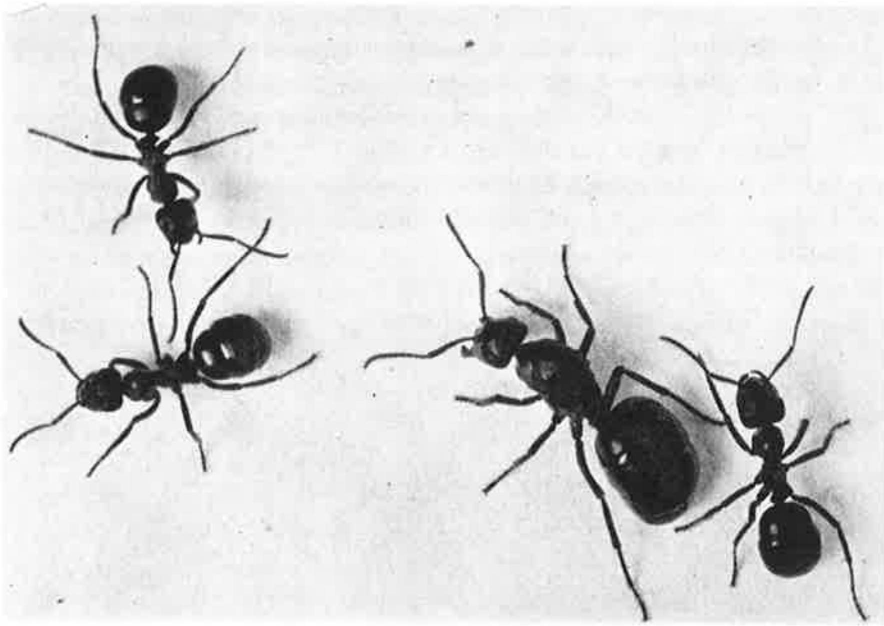
## ANTS

Research into the ants found in our woods was begun as soon as Itbon was established. The red wood-ant was known to be an important enemy of destructive wood insects, and other ant species could also be expected to have at any rate a noticeable effect. That is why we wished to obtain an idea of ant life in the various types of vegetation and of the ecology of the species found.

We have learned from the investigations of QUISPEL (1941) and of WESTHOFF and WESTHOFF-DE JONCHEERE (1942) that there is a close connection between the composition of plant associations and that of the ant fauna. Practically every plant association has its own special combination of ants, both in number and type. Consequently, what kind of combination will be found in woods largely depends on the undergrowth. For instance, woods with an undergrowth of oak and birch *(Querceto-Betuletum)* were found to have numerous ants of many different species, while a wood of American oaks in the same region with no undergrowth was seen to be entirely devoid of ants. A wood consisting solely of Scots pine and a beech wood in the same region were also seen be sparsely populated with ants.

A number of species, including the red wood-ants most common in this country, *Formica polyctena* FOERST. and *F. rufa* L. were not demonstrably dependent on the undergrowth. It soon became apparent, furthermore, that the beneficial effect which species that are clearly dependent on the undergrowth for their distribution had been thought to have was in fact negligible. Accordingly, the investigation was narrowed down to the two species named above.

This investigation was assigned to ELTON, though certain sections of the work were done by students. A key point is that it is mainly the colonies of wood ants with many queens (polygynous), which often consist of a large number of nests, that will protect woods from pests. They generally contain far more ants than the colonies with only one queen (monogynous) or even

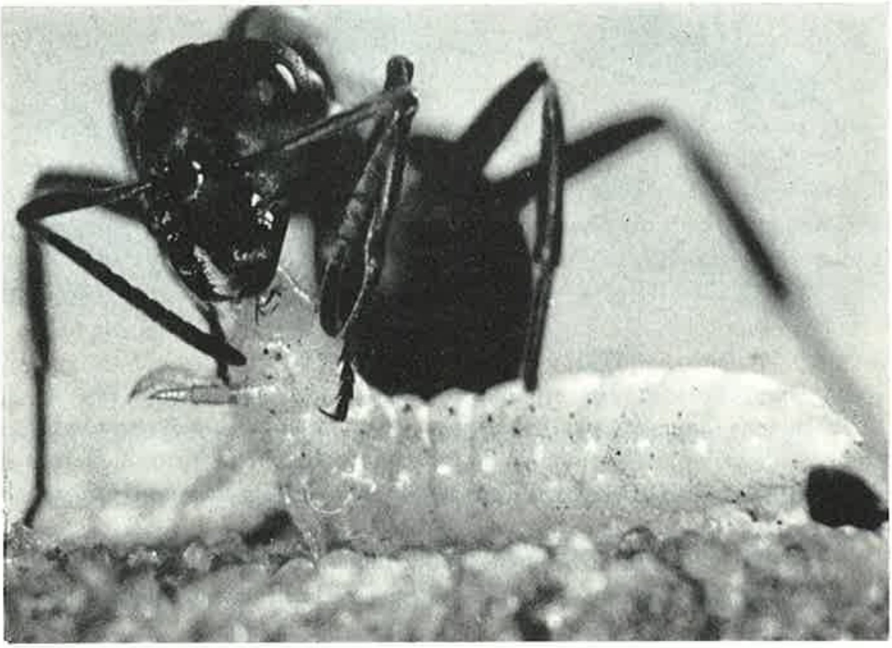


*Formica polyctena:* queen and workers.

a few queens (oligogynous), consisting of one mound. *F. polyctena* is polygynous. There is a monogynous as well as a polygynous form of *F. rufa* – as we shall see later, these two forms will most probably have to be regarded as separate species.

It has been observed in the field that colonies of *F. polyctena* can suddenly expand very considerably. Many new nests are built, so that giant colonies are formed, sometimes with more than 100 anthills, which are often very far apart and are connected by ant tracks. What causes such expansion is still very much a mystery. The huge colonies can disappear as quickly as they came, which at one time was attributed to the collecting of cocoons for fish and bird food. Some people erroneously call the cocoons 'ants' eggs'. But even if the cocoons were not taken, large colonies disintegrated within a few years to single mounds very far apart and no longer connected by ant tracks. This was observed, for example, in a particularly large colony near Arnhem after the war. Degeneration is sometimes observed in small colonies, too, often coupled with the occurrence of pseudogynes (workers with enlarged thoraxes). Whether there is any connection with the presence in the nests of one of the *Atemeles* or *Lomechusa* beetles is uncertain. Research into the *Atemeles* problem was carried out by Kruizinga and Holleman. As a general rule, *Atemeles* larvae and pseudogynes were found in degenerating colonies. Nevertheless there were colonies without *Atemeles* but with pseudogynes, with *Atemeles* but without pseudogynes, and degenerating colonies with neither *Atemeles* nor pseudogynes.

Of course the absence of *Atemeles* or of pseudogynes can never be established with certainty. If they are not found, it does not mean that they are not there. Furthermore, they might have had a destructive influence on the colony in a previous year. Research into the decline of colonies is by no means complete.



A worker ant feeding a larva of *Atemeles*.

*Formica polyctena* may spread over a large area, albeit very slowly, due to the disintegration of giant colonies into nests great distances apart. Later on, they may form the nucleus of a new large colony. The presence of colonies well outside an area where large colonies may have existed shows that there are other ways of establishing colonies. However, the fact of the 22 known colonies of *F. polyctena* in and round the Hoge Veluwe National Park at least 15 date from before 1940 and some even from before 1914 makes it clear that this is a rare occurrence. It is uncertain whether the remaining 7 colonies were in existence before 1940, developing perhaps from earlier giant colonies, or whether they were formed in the last 25 years.

The young queens of the various species of red wood ants are incapable of founding a colony independently; to do so they must be adopted by a colony of a different species. Species that adopt others are called host ants. Contrary to expectations, neither very small colonies still in the development stage nor colonies containing another species besides *F. polyctena*, have been found so far.

When founding colonies artificially by the traditional method (i.e. by taking ants, brood and nesting material from a number of *polyctena* mounds and depositing them on a prepared site), it was discovered that results could only be expected if a large stock of ants, etc., was used. Therefore it would seem that host ants are necessary to help the colony in its early days. It is still uncertain what species act as host ants to *F. polyctena*. Many biologists think it is a black ant, *Serviformica fusca* L., but other species, for example *Formica rufa* or *F. sanguinea*, might also act as such.

We have learnt from a preliminary investigation that queenless *rufa* colonies, and even *fusca* colonies, are initially very intolerant of *polyctena* queens. However, their intolerance lessens considerably in captivity if a number of *polyctena* queens are offered in succession. *Sanguinea* turned out to be less intolerant. Queenless *rufa* colonies have also been found in the field; most of them were colonies founded artificially and not provided with a queen. They have never been observed to have adopted *polyctena* queens. They all died out in the end, though some of them not for several years.

*Polyctena* colonies always possess large numbers of queens, yet they are far from tolerant when called upon to admit young queens. Young queens born in the nest swarm off for mating. If they are prevented from doing so, the workers no longer regard them as belonging to the nest; they attack and kill them. Unless this rule is not so generally followed as observation suggests, one gets the impression that the increase in the number of queens and replacement of the old queens is achieved by the adoption of young queens from outside. How this is done is not known. Once we found young queens with a few worker ants under a clump of moss. When these queens were taken to the nest they were killed. Once or twice a number of young females known to have been adopted were found in a nest, and when they were put on the top of the same nest they were killed. Adoption would therefore seem to be a gradual process.

*Polyctena* queens have always been accepted by colonies in the laboratory, although a certain amount of skirmishing has always been observed. Queens which had been pre-adopted by part of the colony were received in the same way as queens that had not been pre-adopted. But if a female was introduced into a colony one day after the group of ants that had pre-adopted her had joined the colony, the queen was regarded as belonging to the nest without more ado. There are a number of indications that a queen must have the same scent as the workers if she is to be adopted. BIJL conducted some tests from which it appeared that the workers must know a queen before they will accept her. Attempts to get queens adopted by colonies in the field by first bringing them into contact with increasing numbers of workers to give them an opportunity of acquiring the scent of the nest from them, and perhaps to transmit their own scent to the workers, have so far been unsuccessful (MIEDEMA and BAKKER).

ELTON (1956b) did find, however, that there were two periods during which adoption took place quickly and without difficulty:

1. in the early spring, immediately after their winter rest, when the ants are 'sunning themselves' in closely packed groups on the mounds. The length of this tolerant period differs greatly from colony to colony. As already stated, tolerance is shown only to members of their own species.
2. when new colonies are founded artificially. These colonies are tolerant until they have become established. Here, too, tolerance is shown only to queens of the same species.

Not only *F. polyctena* but also *F. rufa* possess the power to distinguish between queens of their own species and those of other species during the periods mentioned under 1 and 2 above, and this phenomenon has been used to illustrate that the polygynous and monogynous forms of *F. rufa* most probably are separate species.

These periods were determined in two ways:

*a.* Queens were offered to the colonies in small cages. The queens could not get out of the cages, but the workers could pass in and out.

*b.* In the following spring, 6 to 12 months later, the nests were excavated and the queens counted. The queens had been marked by cutting a small piece off one of the antennae. Laboratory experiments suggest that this method of marking reduces the queen's chances of survival. However, the comparability of results is not impaired by this method of marking, as the induced surplus mortality is always the same.

Accordingly, the best way of artificially populating our woods with ants is to add sufficient queens while colonies are being founded. If this is impossible for some reason or other, it can be done in the early spring of the following year. However, this involves keeping the young queens for a year, which was always difficult, because the death rate among the young queens was rather high. Experiments to discover the best way of keepings queens resulted in some improvement, but the average death rate remained fairly high.

*

Ant research has shown that artificially populating newly wooded areas may well be worth while, since *F. polyctena* are slow to spread unaided. Whether it would be worth while in areas where the species is already present, though small in number, is uncertain. Before we can decide whether it is, we shall have to try to discover why *polyctena* is not more numerous. If it is the result of a built-in mechanism for regulating the *polyctena* population, there would be no sense in trying to spread them artificially, because the increase in the population would bring the mechanism into operation and the population would return to its old level. If the low level is the result of destruction by human agency, there would be no sense in artificial re-population unless the cause of the destruction, for instance the large-scale robbing of ants' eggs, is eliminated. If it is the result of predators, of which the woodpecker is the most formidable, it might be useful to protect the ants from them. Practically all the nests in the Hoge Veluwe were regularly checked to increase our understanding of the problem. Some of the nests were robbed experimentally at regular intervals but in moderation; pyramids of wire gauze were placed over others to prevent woodpeckers from preying on the ants.In addition, a large number of ant colonies have been established in parts of the Park where there were very few of the species, or none at all. Provisionally, the experiments show that:

1. the nests from which brood was taken developed in the same way as nests which were not robbed;
2. protecting nests against woodpeckers had no noticeable effect on nest development, at any rate on nests of several years standing;
3. the tendency both to grow into large colonies and to decline has been observed in existing and in newly founded colonies alike. Almost all the giant colonies existing in 1940 have gone through periods of decline since then, followed in some cases by periods of partial recovery.

It is obvious from the above that one or more natural factors affect the death rate, factors the importance of which has hitherto been underrated. They might well prove obstacles to maintaining the high ant population density now thought desirable. We shall have find out by research at what level the ant population of our woods is regulated by nature and what is the lowest population density at which they are economically important in our woods. Future investigations will have to be conducted primarily to discover the causes of colony decline.

## Wasps

We had learned from observation that some species of wasps might play an important part as predators of various insects and other small animals.

They had already been seen to prey on flies, bees, bats, moths, butterflies, spiders, and on one occasion on a centipede. It therefore seemed a good idea to instigate research into social wasps. This was begun by KLEINHOUT (1958) and continued later by students (HORDIJK and BROEKHUIZEN) as post graduate studies.

With specially designed equipment the researchers took the prey from the homing wasps and managed with a little practice to determine 90% of the prey.

Of the prey of *Paravespula vulgaris* 27% consisted of insect larvae, chiefly caterpillars and sawfly larvae, and 38% consisted of adult flies; 80% of the prey of *Dolichovespula saxonica* was flies and only a small percentage insect larvae.

To determine the importance of this predation in the field we had to have a picture not only of the composition and quantity of the prey but also of the hunting range of each colony, the density of the nests and the density of the prey in a given area.

The results of tests to show the hunting range were difficult to interpret. It was reasonably easy to determine the density of the wasp population and, as stated above, the composition of the prey. The method of determining the density of the prey has only been worked out for a few species as yet.


A marked wasp removing sand from the nest.

Bumble bees have always been thought to fulfil an important function as pollinators of red clover. As it has generally been assumed that the seed production of clover would be reduced if there were no pollinators, the Central Institute for Agricultural Research at Wageningen instigated research to discover whether colonies of bumble bees could be put into portable hives and placed during the flowering period near the plants to be pollinated, in the same way as bee-hives are. This research was passed to Itbon in 1956 and continued by us up to 1959. It was then temporarily suspended, because the results of some experiments abroad became available, which cast serious doubt on the accuracy of the century-old assumption that poor seed production by red clover is attributable to insufficient pollination. The Institute for Biological and Chemical Research on Field Crops and Herbage at Wageningen investigated this point at our request, and their interim findings seem to indicate that pollination is seldom the limiting factor in seed production. If this is the case, there is no point in increasing the bumble bee population.

Our part of the above research was carried out by ELTON.

The chief visitor to the red clover in the vicinity of the Institute appeared to be the Common Carder Bee (*Bombus pascuorum* SCOP.) and a less frequent visitor was the Small Garden Bumble Bee (*Bombus hortorum* L.). The Large and Small Earth Bumble Bees (*Bombus terrestris* L. and *B. lucorum* L.) did visit the flowers but played no part in pollination. For this reason *B. pascuorum* was singled out for special study. The object of the investigation was to discover to what extent it would be feasible to increase the bumble bee population by fostering the founding of nests in the field or by having nesting boxes available containing colonies of bumble bees that could be placed near the red clover during the flowering season.

Nesting boxes placed outside were populated exclusively by *Bombus hypnorum* L., which were not observed on red clover. An attempt to provide domiciles in the field specially attractive to *B. pascuorum* was unsuccessful. An attempt was made in the laboratory and in a greenhouse to induce the Common Carder Bee queens to make nests in boxes provided. In the laboratory this was done according to the 'HASSELROTH' method, which had been fairly successful in Finland. In the greenhouse the nesting boxes were open to the queens, which could fly round freely and had access to wild flowers which in the natural state are specially favoured by bumble bees.

By both means 30% to 50% of the queens could be induced to start nests. In the laboratory, however, they failed to develop beyond the initial stage. When placed outside, they developed a little further, but most of the queens disappeared for good sooner or later. At first it was assumed that the queens had perished while searching for food, but later it came to light that they did not return to the nest of their own free will. Nesting boxes are probably so unattractive as nesting places that in many cases the attraction of natural nesting places overrides the pull of existing nests. This probably also explains why the deserted nests were never adopted by other queens, although *B. pascuorum* queens easily adopt strange nests of the same species and are accepted without protest by the workers, as other experiments showed.

In the greenhouse, the nests developed normally, although the death rate among queens was high because of their efforts to capture ready-made nests. Very often the queens were found to have been superseded by others, in one case it happened five times in succession. This clearly indicates that queens are constantly struggling among themselves for the possession of nests. We gained the impression that bumble bee queens prefer ready-made nests at any stage of development to starting from scratch. For this reason colonies must be removed from the greenhouse as soon as they are established. However, as described above in connection with the colonies founded according to the 'HASSELROTH' method, if they are placed outside, a large number will be deserted by the queens.

We have already seen that queens very readily adopt the brood of other queens. It was also easy to get a queenless colony to adopt a queen. In a few cases we actually succeeded in starting a colony with one queen and a few workers captured outside. As stated above, the fact that queenless colonies in nesting boxes are not adopted out in the open is probably due to unattractiveness of the boxes and certainly not to any lack of the inclination to adopt.

The breeding of bumble bees to increase their population density in fields of red clover therefore does not yet seem to be a practical proposition. The chief reason for this is our lack of knowledge of what the queens are looking for when selecting their nesting places. Accordingly, that is the first problem that should be tackled when investigations are resumed.

Something else was noticed, however, that suggests another avenue of approach. The bumble bees found in the nesting boxes we put outside were mainly *Bombus hypnorum* L. When a very vigorous colony of these bees was brought in to the Institute garden and many young queens had developed from it, many of the nesting boxes were found to be occupied the following spring. Perhaps we may infer from this that the more hibernating queens there are the more natural nests there will be the following spring. If this should prove to be the case with the Common Carder Bee, too, it might be possible by additional feeding to get certain natural nests to expand into very large colonies producing many young queens, which would automatically lead to an increase of the population density the following season. This holds out prospects for further research. One difficulty would be that one would have to know a year in advance where red clover was to be sown, and that is often impossible to ascertain.

However, as we have to assume that a denser bumble bee population is of no use for pollinating red clover, resumption of the research work will only be economically justified if it can be shown that it would be conducive to the pollination of other plants.

*Chapter 4*

# POPULATION DYNAMICS

Quite soon after the establishment of Itbon, our research on insect pests in forests revealed that we did not know enough about the causes of fluctuations in the population density of insects to enable us to understand the incidence of epidemics, let alone give the forest a certain resistance to them. Accordingly, an investigation was first started into the principles of population dynamics. We were aware that the widening of our knowledge would also benefit agriculture and horticulture, which often suffer much more as a result of injury by insects than our woods do. But forest insects were more suitable for such research than ones that were harmful to agriculture and horticulture. For plantation crops have been impoverished to such a degree by far-reaching human interference that many factors which elsewhere tend to limit the fluctuations in insect population density have either been rendered less effective or eliminated altogether. So the influence of those factors can be better studied in forests.

At Itbon it was VOÛTE (1943b) who first tackled the problem. Field observations and a study of the literature on the subject led to the formulation in 1942 of the following hypothesis: As a community of phytophagous forest insects grows, there will be a level at which the species is so numerous that it becomes worth while for polyphagous predators (i.e. predators that feed on many species of insects) to go in search of them; later on M. E. SOLOMON called this a 'functional response' on the part of the predators. Death due to predacity will rise in consequence of such specialization. The result may be that the population is reduced to its original level. This was observed in the field, when studying the effect of woodpeckers on *Pissodes piniphilus*, of mice on *Diprion pini* and *Pristiphora erichsonii*, and of ants on *Pachynematus scutellatus*. In all these instances mortality in the non-adult phases due to specialization by the predators was very high, reaching 95% and in some instances nearly 100%, as against a mortality of for instance 5% in the absence of such specialization (see the relevant paragraphs in the chapter on forest entomology). If the population goes on growing, the polyphagous predators become satiated. Still greater specialization on the prey concerned would result in one species constituting virtually 100% of the food. In such cases specialization is seen to decrease, reducing the predator's significance as a mortality factor.

High population density improves conditions for monophagous predators and parasites, and for parasites that complete their entire development on the species in question, for such predators and parasites themselves multiply as their prey increase in number. SOLOMON calls it the predators' 'numerical response'. In a few generations they outnumber their prey (hosts) and reduce their density to a very low level. (VOÛTE 1946e.)

VOÛTE called the density limit within which polyphagous predators can control the population the 'natural' population density, corresponding more or less to SCHWERDTFEGER's 'eiserne Bestand'. The period before the outbreak of the pest, during which the effect of these predators declines again owing to satiation, resulting in an extra rise in the number of the insect concerned, he termed the 'phase of escape' of the outbreak; the eventual decline of the population to a low level he called the 'crisis' (see Fig. 1). A crisis need not necessarily be due to predators or parasites. Other possible causes are disease, lack of food or a combination of all these factors.

VOÛTE's hypothesis takes very little account of the condition of the host

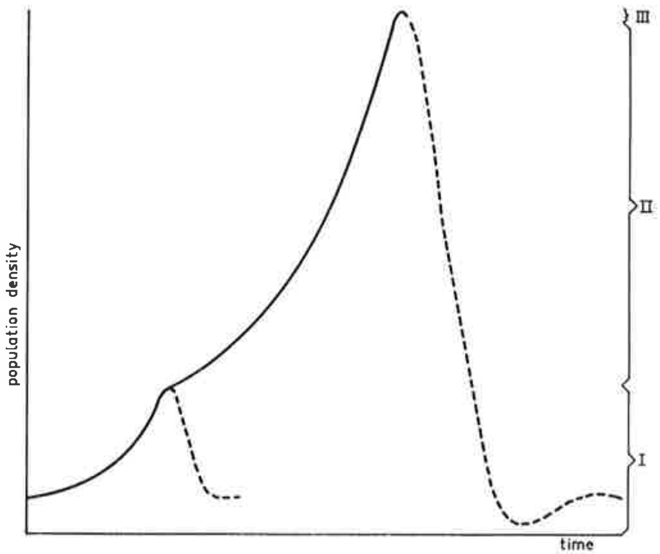



Fig. 1 (VOÛTE, unpublished). – Scheme showing development of an outbreak. I = natural population density: population growth may be stopped by polyphagous predators specializing on abundant prey. II = escape phase: effect of polyphagous predators diminishing; monophagous parasites and predators developing rapidly. III = crisis: population reduces to low level by monophagous predators and parasites, by diseases, by lack of food or shortage of other requisites. – – – – – = reduction of the population.

plant and the effect of that condition on population growth. When it was formulated, those factors lay more of less outside the field of view and the animal community was regarded as the principial regulating factor. Yet even as long ago as that, many of our own observations had indicated that the host plant played a principal part, for instance in the case of *Coleophora laricella* and *Evetria buoliana* (see Chapter 2).

The hypothesis called for further analysis and in 1943 we were fortunate enough to be able to enrol TINBERGEN as a member of the Itbon staff. He was given the task of ascertaining the effect of birds as predators on the mortality of different types of prey in varying densities. He took the tit as his main object of investigation. He worked at our Institute until 1949. After that he became a lecturer – and later professor – at Groningen, whence he continued his research, at first using Itbon's apparatus. The research carried out at Itbon and its subsequent continuation are regarded here as a single undertaking.

For the purpose of that research a method was devised whereby it was possible to determine the density, in the crowns of forest trees, of the phytophagous insects devoured by birds. Samples of twigs are first taken from the trees and the insects on them counted. If the average number of twigs per surface unit of the wood is known, the density of the various species of insects under consideration can be calculated. The density of the birds is then found by counting and recounting the number of singing male birds in the early hours of the morning.

That was how the population densities both of the birds and of their prey were ascertained. Once the consumption per bird had been recorded, the data indicated:

1. the preferences for the various types of prey;
2. the predator's effect on the mortality of the various types of prey;
3. the effect of the density of the prey on predacity and consequently on mortality.

A method devised for ascertaining the quantitative and qualitative composition of the nestlings' food is worth describing. Nesting-boxes were hung up in a wood. As soon as the male tits had defined their territories, the wooden back wall of each nesting-box was replaced by a glass plate and the box placed against the wall of an observation hut ($1 \times 1 \times 1$ m) opposite a peephole. This enabled the tits to be observed and, since the potential prey animals were known, the observers managed to record almost every insect fed to the young ones. When the observers were well trained, they were able to obtain almost equally good results by watching the nesting-boxes from an observation hut through a telescope. This was the only way of observing the tits that did not use the nesting-boxes.

The tits were seen to be partial to certain species of prey, whereas they accepted others (for instance, *Diprion pini)* somewhat reluctantly; accordingly, we were able to draw up a 'preference' index. It was also noticed that when density was very low the birds would snatch prey when they happened to come across it. When the density of the prey rises, the bird develops a certain 'search pattern'; relatively the bird finds a large number of them. The mortality, expressed as a percentage, then rises. If the density rises still further, not only is the bird satiated but it begins to seek a more varied menu for its young, thus causing a drop in mortality. In the light of these facts mortality, in its dependence on the density of the prey, was represented by what C. S. HOLLING calls a 'peaked curve'. In the case in question the peak was too low to have any regulating effect on the numbers; it was namely 35%.

The field observations mentioned in the second paragraph of the chapter, according to which specialization on numerous prey led to a far higher mortality percentage, were made with predators other than tits – namely woodpeckers, mice and ants – the first two moreover in winter, whereas the 35% found by TINBERGEN was the result of summer observations. As a

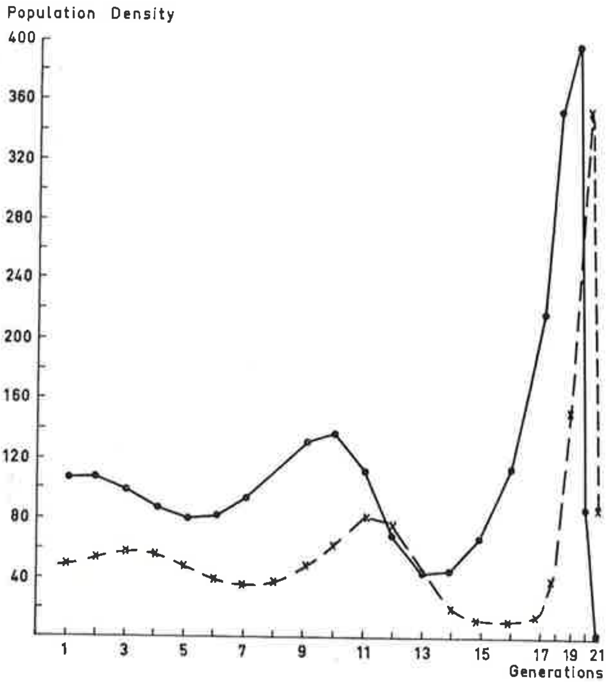



Fig. 2 (VOÛTE, 1964b). – Interaction of host and parasite: fluctuations with increasing amplitude.

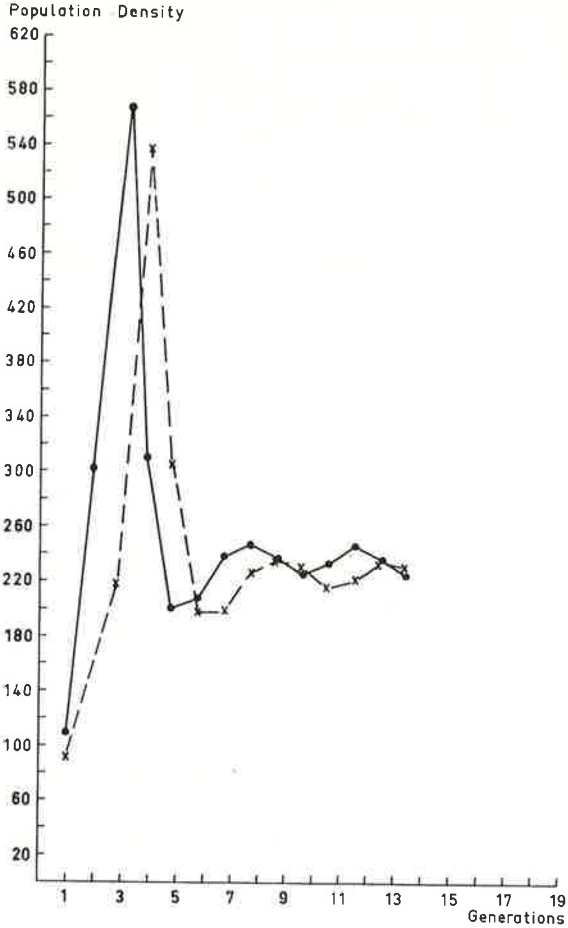



Fig. 3 (VOÛTE, 1964b). – Interaction of host and parasite with immigration of fifty hosts per generation: fluctuations with decreasing amplitude.

matter of fact, the predacity of woodpeckers and mice during the summer months was not high either. Felled trees, with many insect larvae under their bark, were not visited by woodpeckers very frequently until winter. During the cold season the food for all the predators then active becomes more and more scarce. Accordingly, the urge to vary their menu will abate and they will tend to seek more abundant prey. In fact, TINBERGEN's observations also showed that in very severe weather tits sometimes take an extremely heavy toll of their winter prey [1].

[1] TINBERGEN, L. (1960), The dynamics of insect and bird populations in pine woods. – Archs néerl. Zool. *13*: 259–343.

Whereas predacity according to the 'peaked curve' found by TINBERGEN was not in itself sufficient to act as a regulating factor, calculations showed that in combination with the effect of parasites, as calculated by A. J. NICHOLSON, it may act as such [1]. Under this system even a slight increase in predacity, when the population density is growing, is enough to cause the fluctuations in the population densities of host and parasite (see Fig. 2) to diminish instead of increase. Further calculations revealed that other factors such as immigration can have a similar effect (VOÛTE: Minutes of the meeting of the Population Dynamics Discussion Group of the IUFRO, held at Zagreb in 1954) (see Fig. 3). The extent to which this occurs in nature has not yet been ascertained by observation.

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When TINBERGEN left Itbon for Groningen in 1945 he was succeeded by KLOMP, who was given the task of finding out how regulation takes place in the case of species which, though always numerous, never constitute outbreaks, at all events, not in the Netherlands. In consultation with TINBERGEN he selected for the purpose the Pine Looper Moth, *Bupalus piniarius* L. In our country this species, known in Germany as an insect pest of the first order, meets the requirements entirely.

KLOMP [2] showed by calculations that an insect species the population density of which fluctuates, as does *Bupalus*, cannot be kept at a constant population level merely by the chance succession of good and bad years. If that were the case, the species would die out after relatively few generations (see Fig. 4). So there must be a regulating mechanism, i.e., a mechanism whereby when the population density rises mortality increases or reproduction decreases and when the population density falls the reverse takes place.

Research was first carried out to discover the extent to which parasites could constitute a regulating factor. It was found that the little wasp *Trichogramma* and the parasitic flies *Eucarcelia* and *Blondelia* had the greatest effect. *Trichogramma* is a general egg-parasite and develops far more rapidly than *Bupalus*. So the tiny wasps that hatch in *Bupalus* eggs infect the eggs of other insects, and the density of the generation that infects *Bupalus* eggs is governed by the presence or absence of other insects' eggs (KLOMP 1953b). Therefore, little can be expected of this species as regards regulation. *Eucarcelia*, on the other hand, was found to possess a development mechanism

[1] TINBERGEN, L. a. H. KLOMP (1960), The national control of insects in pine woods. II. Conditions for damping of Nicholson oscillations in parasite-host systems. – Archs néerl. Zool. *13*: 344–379.

[2] KLOMP, H. (1962), The influence of climate and weather on the mean density level, the fluctuations and the regulation of animal populations. – Archs néerl. Zool. *15*: 68–109.

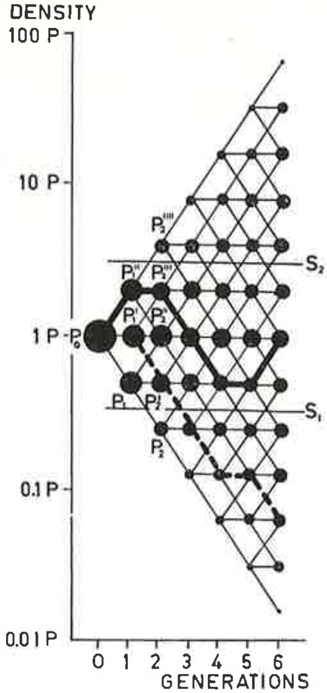


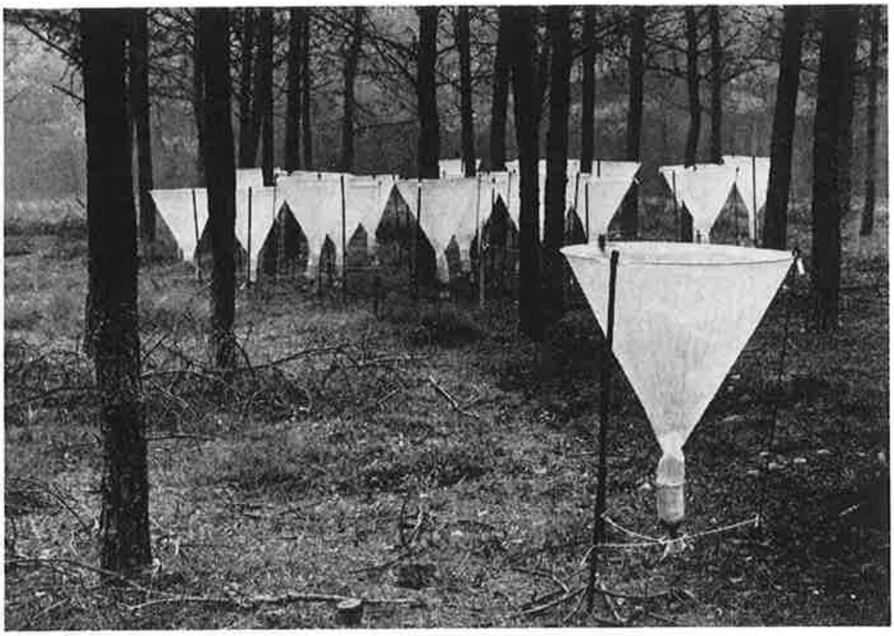

Fig. 4 (Klomp, s. footnote). – Representation of the drift of population density in a simple model, if the net rate of reproduction is only determined by density-independent factors. Above $S_2$ the population dies out due to starvation, and below $S_1$ because the sexes are unable to find each other. The probability that the population fluctuates between $S_1$ and $S_2$ declines at each following generation. $P_1$ = first generation, $P_2$ = second generation, etc.

enabling its generation to follow a course quite parallel to that of *Bupalus*. In *Bupalus* it has one annual generation. But if it develops in a looper with two generations a year, the parasite also produces two generations (Klomp, 1958a). It possesses a hormone-controlled mechanism which makes its development dependent on that of its host.

Klomp was appointed professor in Wageningen in 1956 but continued this research work and was soon joined by Gruys, his successor at Itbon.

The population density of the caterpillars was found to affect the egg production of the butterflies in the following generation and the size of the eggs then laid. In the field a connection was observed to exist between the death rate among young caterpillars and the density of the caterpillars in the previous generation. A high density was accompanied by a high death rate.

The ratios found in the field were reproduceable in the laboratory. Heavier cocoons were obtained when the caterpillars were reared separately than when several of them were kept together (see Table 1). Laboratory research also revealed a relation between egg-production and the size of the cocoon. It was not sufficient, however, to act as a regulating factor because, despite the lower egg-production per female, the total population produced more eggs when the density was high than when it was low. But the eggs laid by



Funnels for catching *Bupalus* larvae, which in October drop to the ground for pupation.

Rearing *Bupalus* larvae.

*Table 1*

| | Mean pupal diameter (mm) | Standard deviation of mean | Number measured |
|---|---|---|---|
| Larvae reared singly | 5.38 | 0.03 | 50 |
| in couples | 4.98 | 0.03 | 47 |
| five by five | 4.86 | 0.06 | 19 |

butterflies from small cocoons, and the caterpillars that hatched out of them, had less vitality than those produced by butterflies from large cocoons. De Bruïne and Bungenberg de Jong helped in this research. The difference in vitality is clearly seen from Table 2, which shows the mortality

*Table 2*

| | Treatment of eggs | | | | | |
|---|---|---|---|---|---|---|
| Temp. (C) | 28° | 28° | 25° | 15° | 10° | day 30° / night 4° |
| Rel. humid. | 23% | 75% | 75% | 75% | 75% | — |
| Parent larvae per jar | Per cent. of eggs hatched | | | | | |
| 1 | 14 | 76 | 86 | 90 | 49 | 78 |
| 5 | 2 | 46 | 60 | 61 | 15 | 53 |

among eggs produced by butterflies raised alone and among those produced by butterflies raised in groups of five. The eggs were kept at different temperatures and in different degrees of atmospheric humidity. The same differences are observed among caterpillars that are caused to starve (see Table 3).

*Table 3*

| | Starvation | |
|---|---|---|
| | 1 day | 2 days |
| Parent larvae per jar | Per cent. survival after 10 days | |
| 1 | 62 | 21 |
| 5 | 13 | 5 |

The peculiar density-effect is not due to lack of food, but occurs when the caterpillars meet one another during the night. Only during the first phase is a meeting ineffective. (s. Klomp a. Gruys, 1964.)

For the purposes of the investigation it was necessary to know how certain abiotic factors affected the caterpillars' growth. This was ascertained with the help of A. M. Voûte and Joosten-van den Broek Humphrey. It was observed that temperature and the length of the day affected the number of larval phases, which is determined at an early stage of development.

Using VARLEY and GRADWELL's key-factor method, the regulation of population density was traced to density-governed mortality during the egg-phase and among young caterpillars. Egg-mortality was found to be due to the egg-parasite, which, as stated above, cannot in principle act as a regulator. May it not be that the egg-parasite has a preference for eggs that are in none too good a condition? Or do the parasites make for places where their prey is superabundant?

So the investigation revealed a regulating principle which, as far as we know, had not previously been discovered (KLOMP a. GRUYS, 1964).

*

The population-genetic aspect of regulation has not been touched upon yet.

Population genetics is the investigation of both the qualitative aspects of animal populations and the quantitative, such as the proportional incidence of the various genotypes, the changes in them, and their preservation. In the case of *Bupalus* a clearly deviant form has been observed: a yellow variety which as egg, larva and cocoon is distinct from the green one. The colour of the egg is determined by that of the caterpillar from which the mother has developed. It may well be that the bright yellow colour is a disadvantage, attracting predatory birds. But why the variety is not exterminated as a consequence needs explanation.

DE JONGE started the research into this subject. When he left, the work was taken over by DEN BOER and BLANKWAARDT. They are endeavouring to discover how the yellow variety of *Bupalus* can remain constant at about 3% of the number of green caterpillars. They have already found that yellow is the dominant colour. The chances of survival in the various phases of the yellow variety will be compared with those of the green one; at present they are trying to find out whether the yellow variety is affected differently by predacity on the part of birds and wasps. So far, it would seem that it is preyed upon less. On the other hand, the green cocoons are heavier than the yellow ones.

As stated above, it was originally assumed when investigating insect pests in forests that sufficient food was always available for the insects concerned.

Research on *Cephalcia*, *Diprion* and *Euproctis* (see Chapter 2) showed that this assumption is incorrect, because it is too much of a generalization. The value of the various food-plants to phytophagous insects may vary from year to year. But this does not mean that population density can be regulated at a low level by the food. For that to be possible, the leaves to be eaten from one tree or from trees of one species would need to have different food-values and the insects would need to have a preference for the best quality.

This point is being studied by van der Linde. He fed leaves from different parts of a tree to the Brown-tail Moth *(Euproctis chrysorrhoea* L.), the Gypsy Moth *(Lymantria dispar* L.) and the Lackey Moth *(Malacosoma neustria* L.); marked differences in development were observed. Those insects have a natural preference for the top of a tree, where they develop best. It was also shown that the various food-plants of the Brown-tail Moth, the Gypsy Moth and the Lackey Moth have different food-values, and that the location of the tree affects its value. The range of food-plants and their susceptibility to outbreaks of Brown-tail Moth were mentioned in Chapter 2. But the reproduction and mortality of those three species of moths, bred on leaves of food-plants of the same species but obtained from different places, were seen to vary greatly. Though the research work is by no means completed, it can already be stated that the population density of these species of moths is possibly regulated at a low level solely by the food.

*Chapter 5*

# LANDSCAPE ECOLOGY

The term 'landscape ecology' embraces the ecological problems connected with the structure of the landscape. The subject is dealt with in detail in Chapter 9.

Our investigations concerning areas of waste land were conducted in accordance with the principles of what we now call 'landscape ecology'. They covered the effect of windbreaks on the crops grown behind them and the preservation of typical dune scenery in regions opened up for recreation. There are also many other problems which have a bearing on landscape ecology. One of them is the study of forests insects, because it is becoming more and more obvious that the location of an infestation affects its development. Certain game problems may also be approached from the landscape-ecological angle.

## Windbreaks

The shortage of arable land and the obviously disadvantageous effects of shading and root competition on the yield from land adjoining tree plantings have for a long time been advanced as arguments for the removal of all trees from agricultural regions. On the other hand, it was known that in some other countries, for instance in Russia and Denmark, windbreaks greatly enhanced the production of agricultural crops but this was ascribed to the climatic conditions in those countries and it was not suspected that windbreaks would have the effect of raising production in the Netherlands climate.

Orchards, gardens and nurseries were often damaged by high winds, so many horticulturists were prepared to retain windbreaks. Yet everyone was aware that very little was known of their real effect. Accordingly, our Institute was requested in 1941, at the instigation of E. D. van Dissel (1942), at that time director of the State Forestry Service, to study the problem of windbreaks, especially their effect on the microclimate. The investigation was first carried out by van der Linde in co-operation with Dr. J. P. M. Woudenberg (1946) of the Royal Netherlands Meteorological Institute at De Bilt.

It is natural that windbreaks should have a marked effect on the velocity of the wind and its distribution as it passes across the countryside. Since we lacked the necessary instruments during the war years and since much attention had already been devoted to the subject in other countries, we did very little research in that line, at all events initially.

The tests we made showed clearly that shelter had the effect of lessening evaporation. Broadly speaking, evaporation increased in the zone where the wind was retarded as the distance from the windbreak increased. This is the case on the leeward side up to a distance equal to from 20 to 25 times the height of the break, if the wind blows at right angles to it, and on the windward side to a distance equal to from 4 to 5 times its height (see Fig. 1).

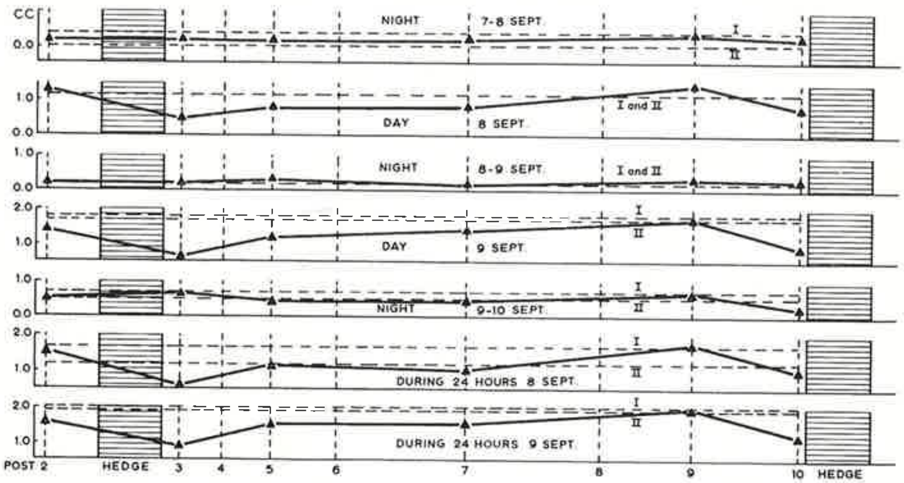



Fig. 1 (VAN DER LINDE a. WOUDENBERG, 1950). – Influence of a hedge on the evaporation of the surrounding area during 3 days.

It should be noted that the reduction of evaporation is regarded as one of the chief reasons for the improved crops in the abovementioned countries.

In 1961, as we had insufficient information on the effect of the shape of windbreaks, including shelter-belts, on the wind field and on evaporation, SYED RIAZ HUSSAIN SHAH (1962) made tests with the help of six models he had designed (two of them are shown in Fig. 2) in a wind tunnel placed at his disposal for the purpose by the Institute for Soil Fertility at Groningen. As Tables 1, 2 and 3 show, the retardation of the wind at various distances behind the screen depended largely on the type of screen; the same thing applied to evaporation (see Table 4).

Tests expressly arranged for the purpose will have to show whether those data can be used in the field. Provisional tests in the Netherlands and abroad tend to confirm SHAH's findings.

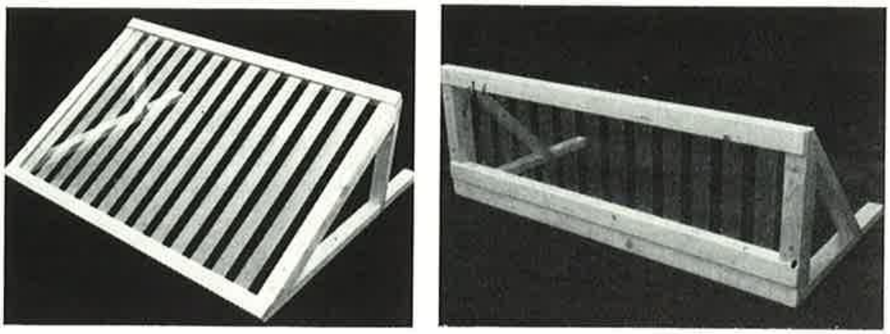


Fig. 2 (SHAH, 1962). – The shelter-belt models Shamin type (l.) en Ali type (r.).

The effect of shelter on temperature proved to be a rather complicated matter. The reduction of turbulence and evaporation when the wind is checked causes a rise in temperature in the daytime, particularly in sunny weather when the wind is moderate. The temperature also rises during windless nights, because windbreaks counteract radiation to a certain extent. This is advantageous, because the severest night frosts occur in calm weather. On the other hand, most of the sheltered zone is cooled during nights when there are light winds. In those circumstances there is a greater likelihood of night frost occurring. (VAN DER LINDE, 1962.)

After the climatological tests, a study was made of the effect of screens on the yields of various crops. VAN DER LINDE, SNIJDERS, VAN RHEE and SHAH all worked on this in turn.

The investigations revealed that the yield followed a trend which was in inverse proportion to the wind speed. Immediately behind the screen (i.e. within the 'root competition' and shading area) lies a narrow zone with a small yield. Beyond that, the yield rises above the level observed in the open field, and still farther on it falls back to that level. (VAN DER LINDE, 1963.) The rise in yield may be slight or it may be very high.

There were slight though clearly noticeable increases in the yields of agricultural crops grown on sandy soil in the South-East of the Netherlands, when they were sheltered. The increases in the case of the sheltered fruit in Zeeland were very high. Taking the fruit yield outside the protected area as 100, the highest apple yield in the sheltered part of the orchard reached 140 (1952–1958 inclusive) and the highest pear yield actually reached 250 (1956–1958 inclusive) (see Fig. 3). The extent of the effect varied greatly from year to year.

*Table 1* – THE INFLUENCE OF THE VARIOUS TYPES OF SHELTER-BELT MODELS ON MODERATE WIND IN THE WIND TUNNEL

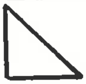
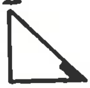
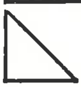
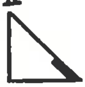
| MODEL | | Wind velocities at the different distances in m/sec<br>Protective efficiencies in % (in parenthesis)<br>5 $H_L$* | 10 $H_L$* | 15 $H_L$* | 20 $H_L$* | 25 $H_L$* | 30 $H_L$* |
|---|---|---|---|---|---|---|---|
| Free wind | | 6.1 (0%) | 5.8 (0%) | 5.9 (0%) | 5.7 (0%) | 5.7 (0%) | 5.8 (0%) |
| Shamim type |  | 2.9 (52%) | 2.7 (53%) | 2.7 (54%) | 3.3 (43%) | 3.8 (33%) | 4.3 (25%) |
| Khalid type |  | 1.6 (73%) | 1.9 (67%) | 2.7 (54%) | 3.7 (35%) | 4.3 (24%) | 4.7 (18%) |
| Ikram type |  | 0.0 (100%) | 1.9 (67%) | 3.1 (47%) | 4.1 (28%) | 4.7 (17%) | 4.9 (17%) |
| Usman type |  | 0.0 (100%) | 0.0 (100%) | 2.7 (54%) | 4.0 (29%) | 4.6 (19%) | 4.9 (17%) |
| Rana type |  | 1.1 (81%) | 1.9 (67%) | 3.5 (40%) | 4.6 (19%) | 4.7 (17%) | 4.9 (17%) |
| Ali type |  | 0.0 (100%) | 0.0 (100%) | 3.5 (40%) | 4.8 (15%) | 5.2 (8%) | 5.5 (5%) |

*Table 2* – THE INFLUENCE OF THE VARIOUS TYPES OF SHELTER-BELT MODELS ON HARD WIND IN THE WIND TUNNEL.

| MODEL | | Wind velocities at the different distances in m/sec<br>Protective efficiencies in % (in parenthesis)<br>5 $H_L$ | 10 $H_L$ | 15 $H_L$ | 20 $H_L$ | 25 $H_L$ | 30 $H_L$ |
|---|---|---|---|---|---|---|---|
| Free wind | | 9.8 (0%) | 9.2 (0%) | 9.4 (0%) | 9.4 (0%) | 9.2 (0%) | 8.9 (0%) |
| Shamim type |  | 5.0 (48%) | 4.6 (50%) | 4.8 (48%) | 5.3 (43%) | 6.0 (35%) | 6.7 (24%) |
| Khalid type |  | 2.5 (74%) | 2.7 (70%) | 4.4 (53%) | 6.0 (36%) | 6.7 (27%) | 7.3 (17%) |
| Ikram type |  | 1.1 (88%) | 2.7 (70%) | 4.8 (48%) | 6.5 (30%) | 7.1 (22%) | 7.5 (15%) |
| Usman type |  | 0.0 (100%) | 2.7 (70%) | 4.4 (53%) | 6.3 (32%) | 6.7 (27%) | 7.3 (17%) |
| Rana type |  | 1.1 (88%) | 1.9 (79%) | 3.5 (62%) | 4.6 (51%) | 4.7 (48%) | 4.9 (44%) |
| Ali type |  | 0.0 (100%) | 0.0 (100%) | 3.5 (62%) | 4.8 (48%) | 5.2 (43%) | 5.5 (38%) |

* In tables 1-4, $H_L$ = distance from windbreak expressed in height of the windbreak.

*Table 3* – THE INFLUENCE OF THE VARIOUS TYPES OF SHELTER-BELT MODELS ON STORMY WIND IN THE WIND TUNNEL.

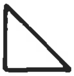
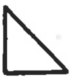
| MODEL | | Wind velocities at the different distances in m/sec Protective efficiencies in % (in parenthesis) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 5 $H_L$ | 10 $H_L$ | 15 $H_L$ | 20 $H_L$ | 25 $H_L$ | 30 $H_L$ |
| Free wind | | 16.8 (0%) | 16.5 (0%) | 16.2 (0%) | 17.0 (0%) | 17.0 (0%) | 17.1 (0%) |
| Shamim type |  | 10.3 (38%) | 9.0 (45%) | 8.6 (46%) | 10.2 (40%) | 10.9 (35%) | 12.7 (25%) |
| Khalid type |  | 6.0 (64%) | 5.3 (67%) | 8.3 (48%) | 11.7 (31%) | 12.5 (26%) | 13.0 (23%) |
| Ikram type |  | 3.3 (80%) | 4.8 (70%) | 8.9 (45%) | 11.0 (35%) | 13.3 (21%) | 14.6 (14%) |
| Usman type |  | 0.0 (100%) | 4.8 (70%) | 7.7 (52%) | 12.7 (25%) | 12.3 (27%) | 14.2 (16%) |

*Table 4* – THE INFLUENCE OF THE VARIOUS TYPES OF SHELTER-BELT MODELS ON THE EVAPORATION IN THE WIND TUNNEL.

| MODEL | | Amount of water evaporated at the different distances (in ml) | | | | | | | Relative Humidity |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 $H_L$ | 5 $H_L$ | 10 $H_L$ | 15 $H_L$ | 20 $H_L$ | 25 $H_L$ | 30 $H_L$ | |
| Shamim type |  | 0.33 | 0.30 | 0.30 | 0.30 | 0.30 | 0.32 | 0.37 | 88% |
| Khalid type |  | 0.65 | 0.58 | 0.48 | 0.61 | 0.66 | 0.73 | 0.72 | 75% |
| Ikram type |  | 0.50 | 0.20 | 0.40 | 0.40 | 1.00 | 1.20 | 1.20 | 74% |
| Usman type |  | 0.20 | 0.20 | 0.20 | 0.20 | 0.32 | 0.46 | 0.42 | 90% |

One of the experimental fields of bean crop with artifical windbreak.

The investigations included making calculations to discover how profitable windbreaks really were. It was found that windbreaks could be planted far closer together than was usual hitherto. The optimum spacing was thought to be the equivalent of from 5 to 6 times the height of the breaks (VAN RHEE, 1959). Many fruit-growers have acted accordingly.

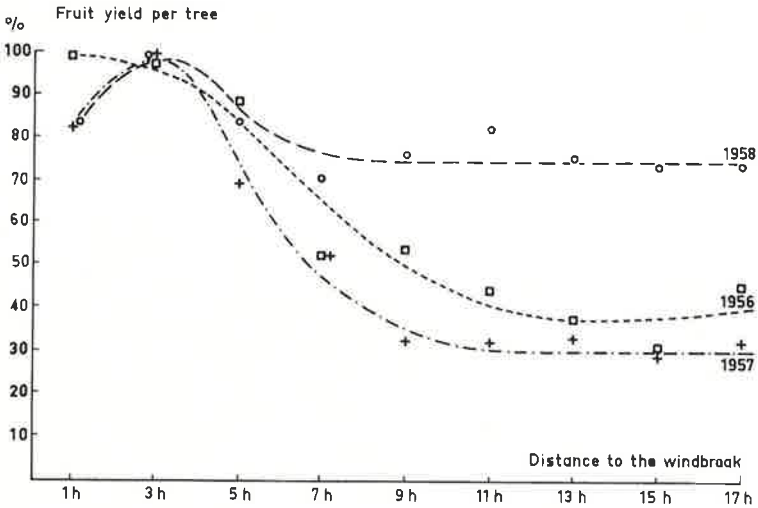
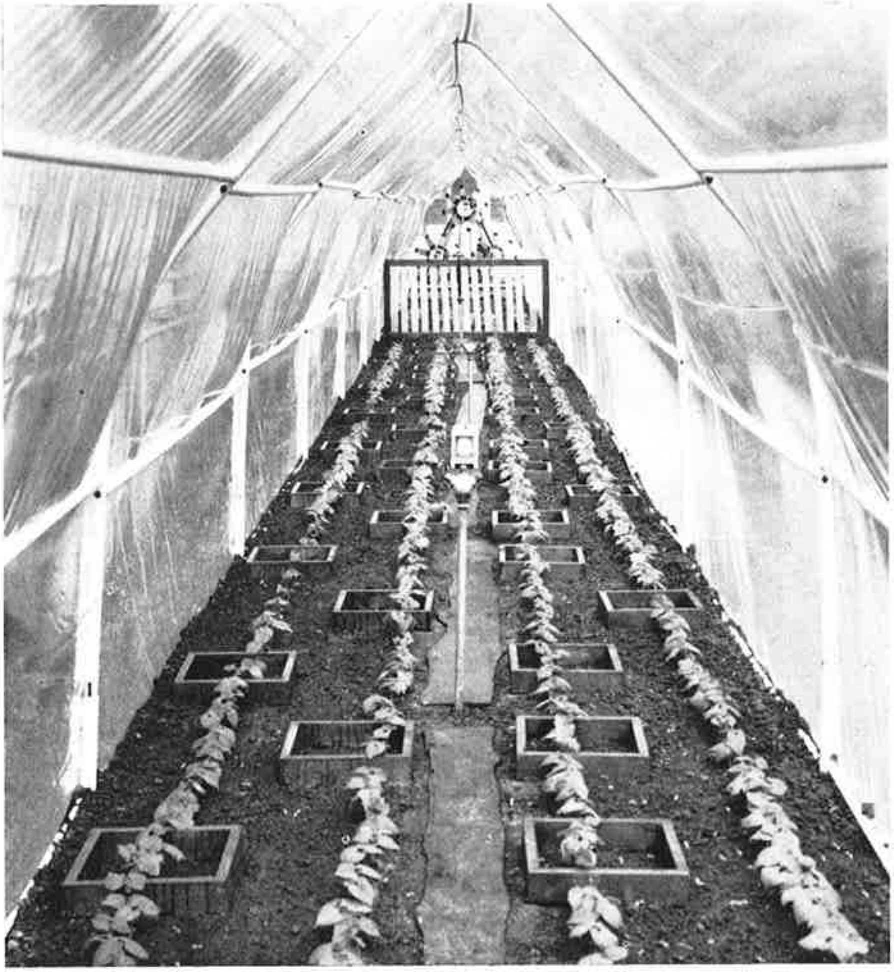



Fig. 3 (VAN RHEE, 1959). – Influence of a windbreak on the yield of pear.



Bean crop growing near to field conditions in the wind tunnel at Wageningen. The pipes with nozzles used for mist irrigation system can also be seen.

In order to analyse the effect of windbreaks more closely, SHAH (1962) carried out an investigation jointly with the Institute for Biological and Chemical Research on Field Crops and Herbage at Wageningen and the Department of Horticulture of Wageningen Agricultural Unversity. The Institute had climate cabinets at its disposal. At the University a wind tunnel was made in a glasshouse; the wind velocity was adjustable and there was a sprinkler system. SHAH carried out his tests on maize and beans. Experimental

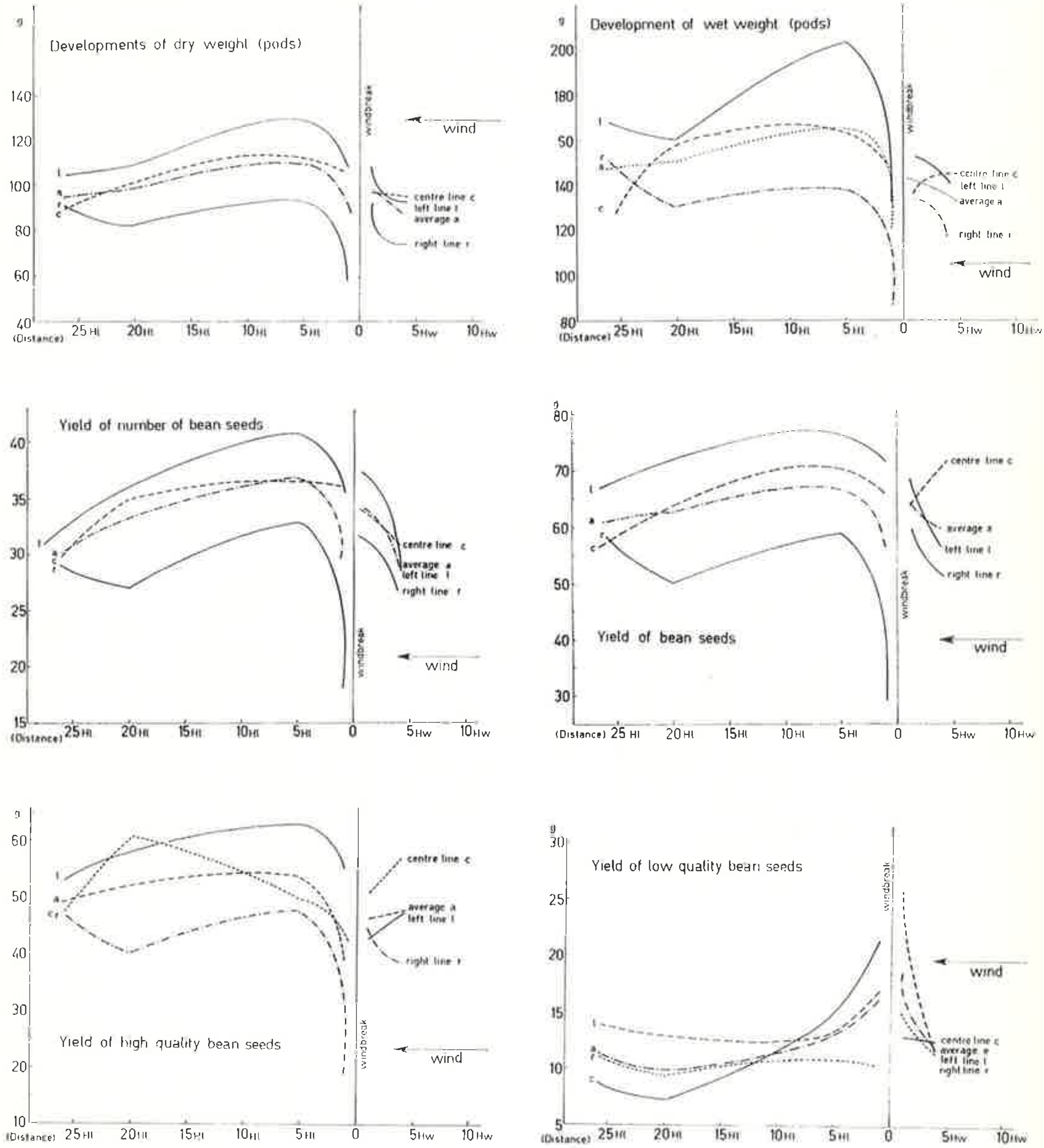



Fig. 4 (SHAH, 1962). – The yield analysis of bean crop 137 days old under the influence of a windbreak in one of the experiments.

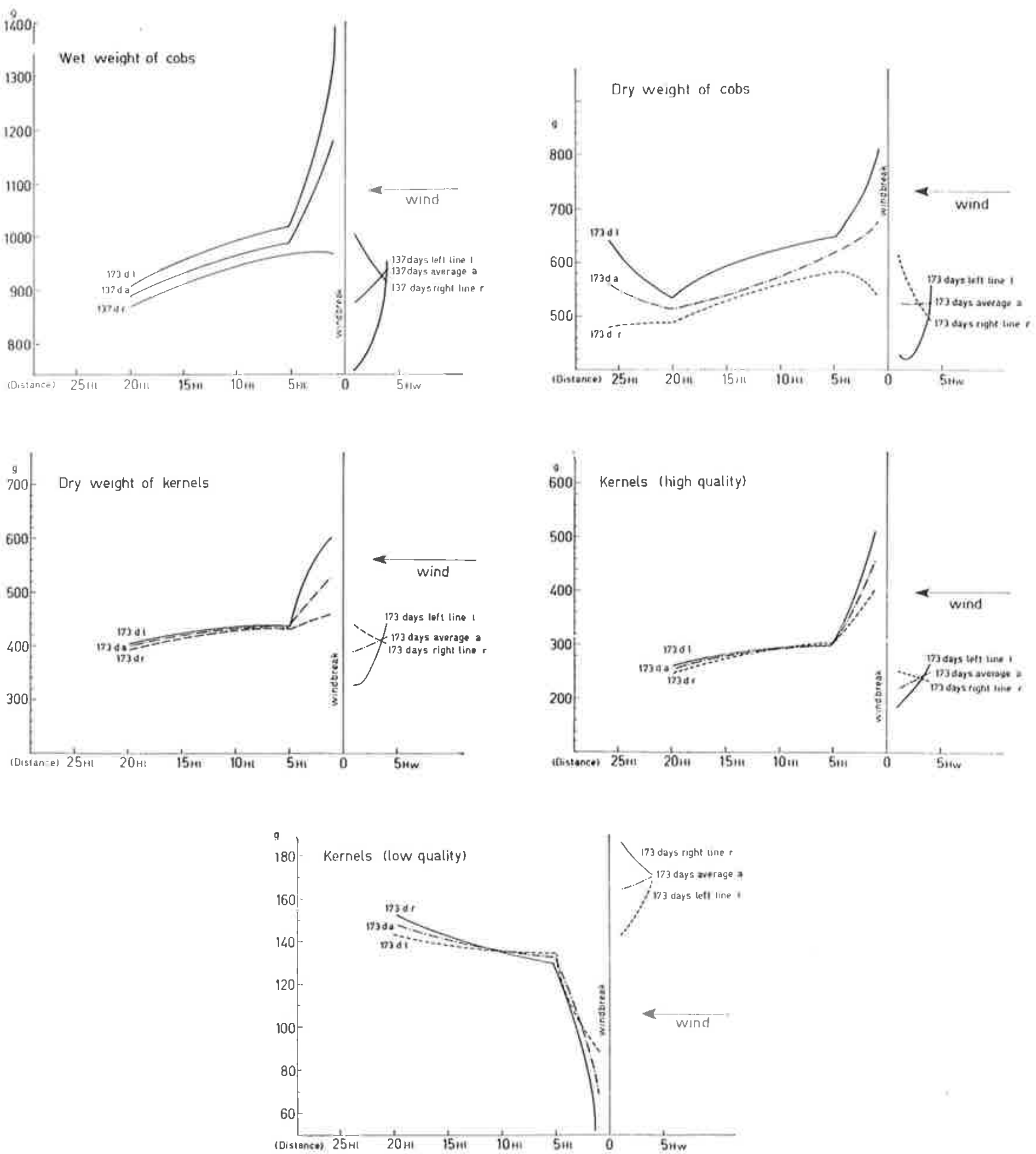



Fig. 5 (SHAH, 1962). – The yield analysis of maize crop under the influence of a windbreak in one of the experiments.

fields provided with windbreaks consisting of strips of transparent plastic were laid out in various parts of the country in co-operation with agricultural and horticultural consultants.

Changes in the meteorological factors due to the screening were studied separately in the laboratory to ascertain their effect on the crop. A higher temperature and greater humidity were found to increase the yield as did the reduction of wind velocity in the wind tunnel. Wind reduction had a favourable effect on temperature, evaporation and soil moisture, and lessened the extent of mechanical damage. Protection enlarged the photosynthetic surface and established a more favourable relation between the plant parts above the ground and those below it. The bean yield was 67% higher in the sheltered part of the glasshouse than in the wind. In the field tests, however, the crop only went up by 12% (see Figs. 4 and 5). That was less than the very great initial differences in growth inside and outside the sheltered area had led the investigators to expect. During the subsequent very wet period (summer 1960) the effect of the screening was largely nullified. The relatively low increase in yield was due partly to the incidence of bacterial disease, which was more serious in the sheltered parts of the terrain than elsewhere.

In both the laboratory and the field, then, yields were seen to be dependent

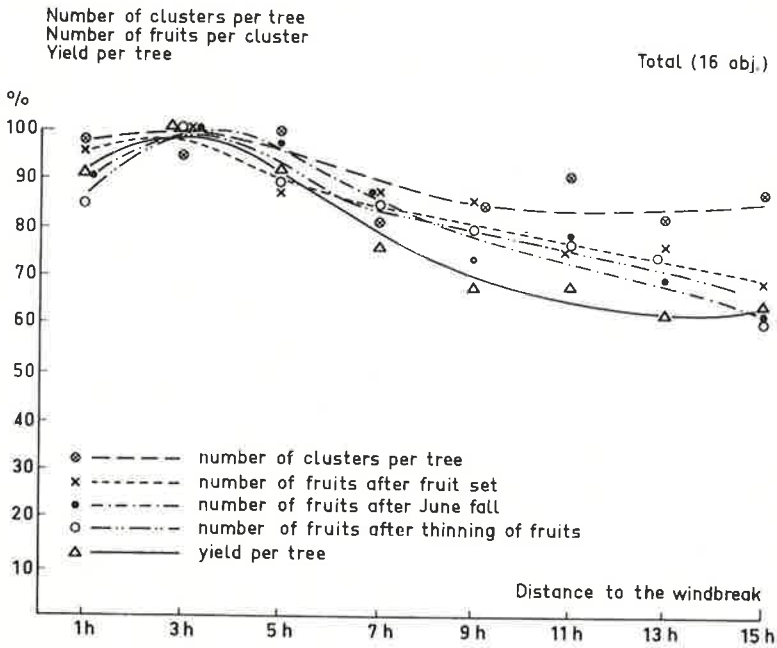



Fig. 6 (VAN RHEE, 1959). – Mean sequence of the formation of fruits of all apple and pear objects.

on the reduction of wind velocity. The greater the reduction the higher the yield. In the zone immediately adjacent to the plastic screen, of course, the yield was not lower, as it is in the zone adjacent to living screens. (SHAH 1962.)

As already stated, fruit trees also respond to screening. A series of counts showed that the crop-increasing effect on apple trees becomes noticeable during fructification. The lower the velocity of the wind, the greater the fructification (see Fig. 6) (VAN RHEE, 1959).

So the reactions of a large number of crops to a reduction of wind velocity were seen to run parallel. But the extent of the effect varied greatly. A survey was therefore prepared by VAN DER LINDE (1963), for practical application in Dutch agriculture and horticulture of the data obtained in the Netherlands and in the adjoining parts of Germany. At the end of the survey it says '... (in our country) an increase in yield in a sheltered area is the rule rather than the exception. There is no increase mainly when both temperature and water-supply are at their optimum levels or exceed them and when the crops being grown are not very sensitive to wind', and 'In practice, this means that there is bound to be an increase in yield in places where shelter is provided, despite 'root competition', shading and the other drawbacks of trees'.

We felt that the investigation of practical problems should be left to the local agricultural authorities, i.e. the advisory services.

## INVESTIGATIONS IN THE DUNES

The dunes play or used to play various parts in the life of our people:

1. They are 'waste land' which, if opened up, might yield a profit.
2. They are a maritime defence.
3. They constitute an important catchment area for Western Holland.
4. They constitute one of our chief recreational facilities.

Dunes are not very good arable land. The most important way in which the authorities endeavoured to make the dunes profitable, one which took recreational interests as well as the stabilization of the dunes into account, was indubitably their afforestation. Now much of Holland's drinking water comes from the dunes and since it was not known what effect the various kinds of vegetation had on the quality of the water, an investigation was considered desirable. The work was assigned to Itbon in 1948; it was carried out successively by VAN DOORN and WIND. In the dune regions near Wassenaar and Leiduin, belonging to the municipal waterworks of The Hague and Amsterdam respectively, trial plots were pegged out in pine-woods and oak-woods and in terrain with natural low vegetation. Using steel tubes 15 cm dia. and 105 cm long, samples were taken at regular intervals from soil-layers at different depths. The water retained in the soil was pushed downwards by adding water at the tops of the tubes, and the outgoing water was collected and analysed. Moreover, every month tests were carried out on samples of subsoil water from two wells in the Noordwijk Forest-holding, one located in an area covered with pines only, the other in a bare dune area. It was observed that the quality of the water was best in dunes with little or no vegetation. (WIND, 1952.)

The dunes were then studied from the point of view of recreation, it being understood that, as they constitute maritime defence works and catchment areas, they must be exposed to as little risk of damage as possible. This meant that a covering of vegetation had to be retained, not only for aesthetic reasons but also to help to prevent levelling and drifting. The research was carried out under the auspices of an ad hoc committee. In so far as it concerned the most effective vegetation, it was carried out by the Department of Plant Taxonomy and Plant Geography of Wageningen Agricultural University (PROF. DR. H. J. VENEMA). The dunes used by the Dune Water-Works of The Hague were dealt with first. A vegetation chart was made of the whole region and the public's preferences for certain types of vegetation were ascertained. A study was made of methods whereby the authorities might help visitors to appreciate the beauties of the terrain. The outcome was a scheme whereby the vulnerable parts of the dunes were to be protected from excessive recreational use by planting indigenous prickly crops and the public was diverted to parts which, though very attractive, were not vulnerable. Consequently, despite the increased popularity of the dunes it was possible to allow the public to walk about freely without fear that much damage would be done. (ADVIESCOMMISSIE DUINBEPLANTING, 1958.) The scheme is already in operation in the dunes near The Hague, and has so far proved successful.

In 1960–1964 a similar investigation was carried out in the North Holland Dune Reserve; it included a study of the fauna with particular reference to hunting, and a study of afforestation for recreational purposes. The latter was necessary in view of the fact that woods maintained for economic purposes have ceased to be profitable and that large numbers of trees in the pine woods have been dying off. People cannot be allowed to roam freely in these dunes; they have to keep to the paths. A number of very narrow, inconspicuous footpaths are being made and retained for the sake of persons who enjoy solitary walks. There are far more solitary walkers than was expected; in fact, their numbers equal those of the 'gregarious' holidaymakers who visit the dunes in groups and do not move about much as a rule. (ADVIESCOMMISSIE NOORDHOLLANDS DUINRESERVAAT, 1964.)

Itbon is beginning to view the incidence of insect pests in our woods more and more as a problem of landscape ecology. Van der Linde and Doom are dealing with the matter.

It has been found that during periods in which they do not constitute outbreaks the Brown-tail Moth and the Gypsy Moth occur only in small and as a rule clearly distinguishable parts of the countryside. Owing probably to the nature of their habitat, the effected trees show retarded growth. The growth of the trees is analysed by means of bore-samples. The leaves are analysed and the soil on the spot is examined.

It is becoming increasingly evident that the site on which trees and forests grow determines whether there will be any mass multiplication of other insects, too, such as *Leucoma salicis* L., *Diprion*, etc. This is also confirmed by the outcome of the research mentioned in Chapter 2 into treating forests of Scots pine with fertilizers and by the fact that certain forests are more sensitive than others to outbreaks; where Scots-pine forests are concerned, this applies to those of the 3rd and 4th site-class qualities.

## *Chapter 6*

# WILDLIFE

The population-dynamic studies on game species undertaken shortly after the War gradually made us realize that there were other problems to be tackled as well. The damage done by game to agriculture, horticulture and forestry and finding means to prevent it soon began to loom large in Itbon's work. The general aim now is to maintain game in such numbers as are economically justifiable and to keep it in the best possible condition.

## Game birds

### *Black Grouse (Lyrurus tetrix L.)*

After the War those dealing with nature conservancy and sportsmen alike were concerned about the future of this splendid bird, since it was found to be constantly dwindling in numbers. Concentrations of Black Grouse were still to be found in several areas but the birds were mainly males. Many theories were put forward to account for the decline, the principal ones being the increasing number of townspeople seeking recreation on the heaths and the abundance of Foxes. None of the explanations given were satisfactory, however, since they were not well founded. Accordingly, it seemed desirable to study the decline of the Black Grouse scientifically. Eygenraam (1948, 1949a) was entrusted with the project.

It was found that Black Grouse defecate every twenty minutes. By tracing the faeses one could tell in what part of the field the Grouse had been and how long they had stayed there. In this way the birds could be followed without being actually seen.

The birds were found to feed mainly on young heather shoots. They are therefore dependent on young heather for their food. They roost on the ground in the low heather. In the daytime they take cover in taller heather and for brooding they require very tall, old heather. They like to rest under the solitary trees – pine trees – dotting heathery regions. As soon as heather of any of the above-mentioned ages is lacking the birds no longer feel at home.

The females die first, so that initially a sharp decline is always accompanied by a considerable disproportion between the sexes.

During the War large areas of heath were mown. The mown heather was used for camouflage purposes. As a result there was a lot of young heather in Holland after the War and little of the heather of varying heights which the birds require. In areas where the heather was not mown, it beeame tall and old. In neither case was the terrain suitable for Black Grouse. When this fact had been established the heather was burnt in places in areas still frequented by Black Grouse (some of them were areas drawing many holidaymakers). The results were gratifying. In all experimental areas the Black Grouse population increased, whereas everywhere else the decline continued; on an average the Black Grouse population quadrupled in the treated areas in two years. (EYGENRAAM, 1957f, 1965.)

### *Partridge (Perdix perdix L.) and Pheasant (Phasianus colchicus L.)*

Following the Black Grouse studies other gallinaceous birds, the Partridge and the Pheasant, have been studied since 1955.

Partridges showed a decline in numbers, just like Black Grouse, but studies undertaken by GLAS (1956a) showed that local influences were to blame; in some places the Partridge population was found to have diminished, whereas it was found to have increased in others.

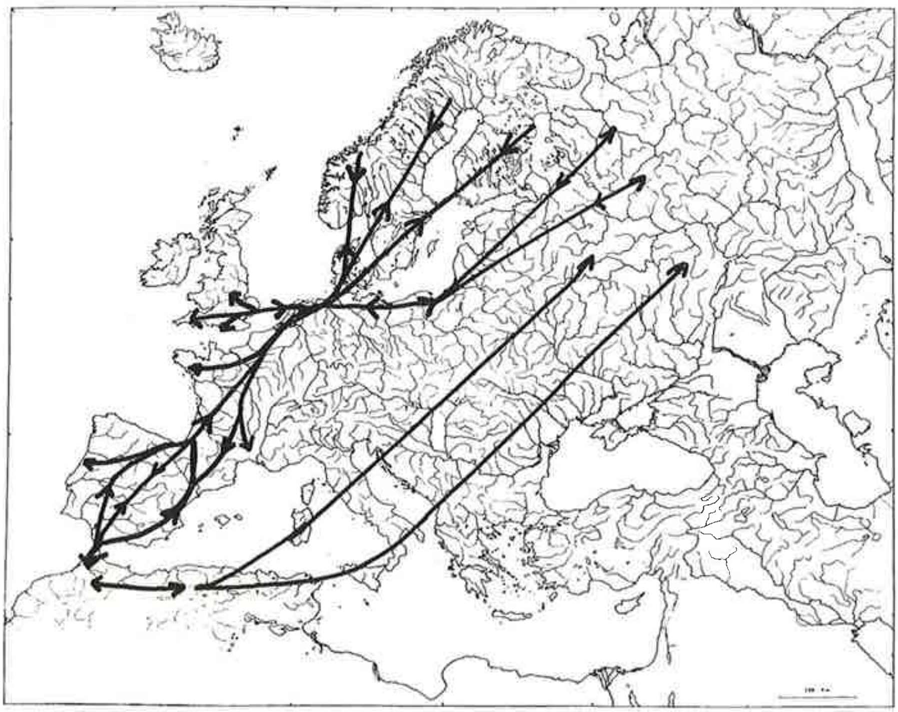
In 1960 DOUDE VAN TROOSTWIJK continued the studies. Statistical treatment of the data on birds shot showed that the decrease in the Partridge population may form part of the ordinary fluctuations in population density observed in the case of many gallinaceous birds and which so far have only been very sketchily explained. The weather during the nesting season is probably one of the causes of fluctuations. (DOUDE VAN TROOSTWIJK, 1964e, d, e, f.)

Pheasants were first studied by VAN DER WAL, who introduced large numbers of ringed birds of different varieties into the various shoots so as to find out whether these would show changes in the migratory urge (VAN DER WAL, 1963). The co-operation of the sportsmen was not quite satisfactory in all cases, however. The sportsmen turned in the rings of birds ringed on their own shoots with fair regularity but they were wary of turning in the rings of birds ringed on neighbouring shoots, probably because they did not like having shot pheasants introduced by their neighbours. Therefore the results are not quite reliable. Presumably the migratory urge is the same for all the varieties, migration probably being mainly dependent on the extent to which the birds are fed during the winter months. If much food is given few birds migrate.

As regards many bird species, but especially in the case of Pheasants, it is important to know the mortality not due to shooting. Few dead birds were found in the shoots, however. The percentage of dead birds retrieved had to be determined. To find this out dead chickens were laid in a number of fields according to a pre-determined pattern. As was expected, the type of vegetation affects the ease with which dead birds are found. Clearly, they are more difficult to find in dense vegetation than in open terrain. The weather, too, plays an important part. The presence of skeletons of dead birds might indicate that the birds died less than six months previously. At the beginning of the experiment the distance at which a dead chicken could be spotted in open terrain (heather and bent) was about 30 feet; at the end of the experiment, 71 days later, the distance was about 7 feet (DOUDE VAN TROOSTWIJK, unpublished).

*Golden Plover (Pluvialis apricaria L.)*

Plover catchers requested EYGENRAAM to find out to what extent their activities affected the Plover population.



Map 1. Migration routes of Golden Plover.

With the assistance of the catchers large numbers of plovers were ringed. Their migratory habits and the areas where they congregate in winter were established on the basis of the reports received on ringed birds (see Map 1). The plovers caught in Holland are mainly of the Northern variety *(Pluvialis apricaria altifrons)*. They constitute only a tiny fraction of the total number of migrants. Since the birds are caught in the early winter months only, many are caught that would have died later on anyway (e.g. owing to lack of food) so that earlier losses can be said to be offset by a lower death rate in subsequent months. Therefore catching hardly affects the population density. This is also demonstrated by the fact that neither a shortening of the period during which these birds may be caught nor a decrease in the numbers of catchers has any marked effect on the population density of the species.

The system of letting the plover catchers 'die out' by not issuing any new licences, which has now been adopted to put an end to the catching and which will cause the occupation to die out, too, by the year 2000, will therefore not materially benefit the plover population. From the point of view of species protection the measure is fruitless and should be viewed in the light of nature conservation policy rather than against any scientific background.

*Dabbling Ducks (Anas spec. and others)*

The Dutch duck decoys were for a long time notorious in other countries for their large-scale catches of Mallards and other Dabbling Ducks. When signing the Paris Convention for the Protection of Birds (1950), the Netherlands agreed to endeavour to abolish the duck-decoy system. Nothing definite was known, however, about the effect of duck decoys on the populations of the various species of Dabbling Ducks. Accordingly, Itbon was requested to study the Dabbling Duck. EYGENRAAM undertook to study the problem.

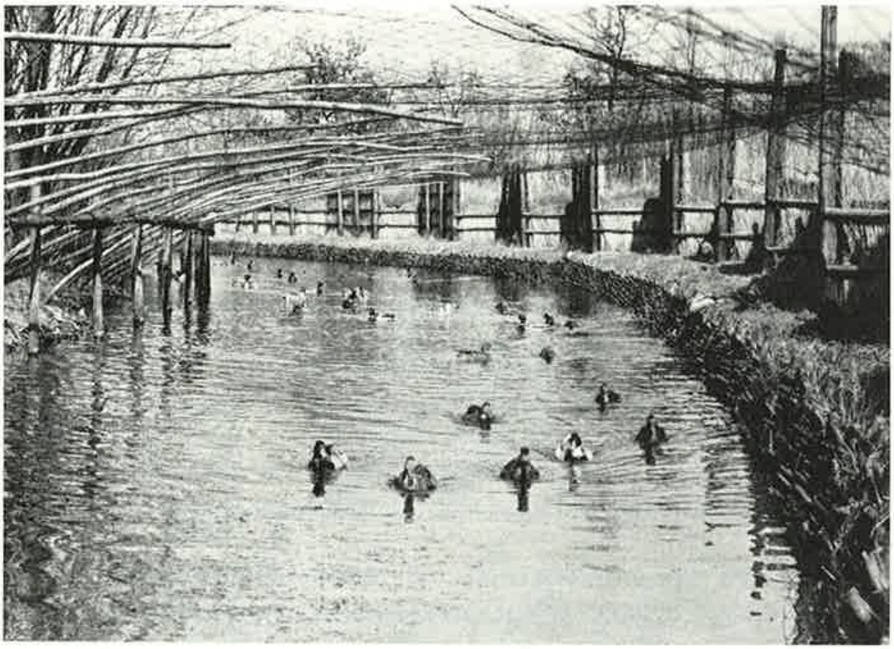
Fluctuations in population densities were deduced from the catches made at the duck decoys. It was clear that there had been no permanent decrease in the density of any of the species of duck in the past fifty years. From this it follows that there has been no excessive shooting or catching of ducks.

By deliberately turning duck decoys into breeding places for the native Dutch Mallard (by placing nesting baskets in the decoy wood, protecting the nests and feeding the adult ducks in winter, i.e. prior to the nesting season), the decoy can also be made to assist the reproduction of the species. If reproduction and consumption figures are compared, we see that a decoy adds about twice as many adult specimens to the Mallard population as it withdraws from it. Duck decoys can therefore be regarded as making a valuable contribution to the Mallard population.

The Dutch duck decoys catch about 200,000 ducks per year, 15 to 20 per cent of which are species of duck other than Mallard. The decoys therefore do not greatly affect the numbers of the latter species, i.e. Teal, Garganey, Pintail, Widgeon, Shoveller, etc. (EYGENRAAM and DOUDE VAN TROOSTWIJK, 1963; EYGENRAAM, 1963k.)

Many duck decoys were employed for ringing Dabbling Ducks. In this way information was obtained on the extent of the habitat of the native Dutch Mallard and on the migratory habits of ducks.

The habitat of the Mallards breeding in Holland has been found to include southern England, northern Belgium and western Germany. So the Mallards living in those areas can be regarded as belonging to a single population. The Dutch duck decoys will affect the entire region.



Duck decoy.

Many migratory ducks congregate in Holland for a longer of shorter period during the winter months. Extension of the area forming a suitable habitat for ducks may be expected to cause the number of migratory ducks to rise. In Holland the habitat was extended as a result of the partial drainage of the former Zuyder Zee. As the new land emerged, the number of birds wintering in Holland increased. When as a result of the progressive cultivation of the new land it became a less suitable habitat for ducks, the number wintering in England increased.

Extension of the areas suitable for wintering definitely seems to have resulted in a rise in the population density of the birds in question. Conversely, the density is determined by the extent of suitable wintering areas.

Eider Ducks hibernating in the Wadden Sea.

The level to which the duck population is regulated during the winter would therefore seem to affect population densities during the entire year. That would mean that under ordinary circumstances the brooding areas of migratory ducks are not fully occupied.

No attempt has yet been made to discover whether duck decoys must also be regarded as additions to the natural wintering areas. If they are, they may increase the population densities of the various species. Ducks are only caught at the decoys during a period ending before the onset of the natural mortality due to wintry conditions. As with the plovers, so with the ducks the earlier losses may be expected to be offset by fewer deaths later on.

From this it will be clear that the duck decoys help to raise the numbers of native Dutch Mallard. They do not reduce the numbers of migratory ducks; on the contrary, there are indications that they also may increase the migratory duck population.

*Geese (Anser spec., Branta spec.)*

Investigations started in 1954. At first they were carried out by Eygenraam, later Doude van Troostwijk took over the work. The studies are based mainly on information obtained from ringed birds. Goose catchers who like the plover catchers will eventually disappear because licences are no longer issued, assist in ringing the geese. Geese are suffering more than any other waterfowl from the rapid shrinkage of suitable winter biotopes. Up to April 1, 1965, the following numbers had been ringed: White-fronted Goose *(Anser albifrons* SCOPOLI) 7669, Bean Goose *(Anser fabalis* LATHAM) 2376, Barnacle Goose *(Branta leucopsis* BECHSTEIN) 783, Pink-footed Goose *(Anser fabalis brachyrhynchus)* 257, Greylag Goose *(Anser anser* L.) 11, Lesser White-fronted Goose *(Anser erythropus* L.) 1.

The migratory routes of White-fronted, Bean and Barnacle Geese were plotted on the basis of reports received about ringed birds (Map 2).

Map 2. Migration routes of White-fronted Goose.

Moreover, it seemed reasonable to assume that the numbers of White-fronted Geese were regulated in the brooding areas in the early summer months.

The Greylag Goose, which had ceased to nest in Holland, was re-introduced. It now nests again in the Lake Yssel (former Zuyder Zee) region.

In Holland birds do a lot of damage to crops every year. Since the problem is not a specifically Dutch one, Itbon arranged an international symposium on the subject in 1954 in consultation with the Wildlife Management Department of the Ministry of Agriculture and Fisheries (Meded. Itbon no. 32, 1957). The various aspects of the problem were discussed at great length during the symposium. The late DR. E. VAN KOERSVELD, whose early death was such a grave loss, made an excellent survey of potentially destructive birds and of the way in which they do damage.

Subsequently, the Plant Protection Service requested its field workers to collect information on the damage done by birds. Their findings were systematized by Itbon.

*Wood Pigeons*

It had long been known that Wood Pigeons *(Columba palumbus* L.) do a lot of damage to crops. They are particularly fond of raiding pea fields, sometimes accompanied by feral pigeons. The damage done by pigeons was regarded as so serious that in 1954 the Ministry of Agriculture and Fisheries decided to offer a reward of 75 cents (approx. 1s.6d.) for every pigeon killed. It was not long before about Fl. 200,000 (£ 20,000) was involded annually. Much damage was done in spite of this, and Itbon was asked to study the Wood Pigeon. The investigations were entrusted to DOUDE VAN TROOSTWIJK.

By computing the number of Wood Pigeons shot per man-week a reliable picture was obtained of the fluctuations in Wood Pigeon population density. It showed that the intensified shooting for the reward did not affect the population density. Wood Pigeon population density proved to be largely dependent on the supply of acorns and beech-nuts in the previous winter. It was also observed that the weather in the previous summer played an important part, presumably because it influences the condition of young birds born in the early autumn. All this goes to show that the population density and consequent damage are determined by the food available in winter.

Reports on ringed birds revealed that Wood Pigeon migration from Northern Europe follows routes lying east of Holland. It would seem that the native Wood Pigeon population is not appreciably augmented by migrants from Northern Europe, even in years when beech-nuts are plentiful. The tentative conclusion is that every winter the native Wood Pigeon population drops to a level determined largely by the quantity of food available. Shooting therefore results in the killing of birds that would otherwise die of starvation

Ringing of a Wood Pigeon.

or migrate. When this was discovered, the authorities decided in 1964 no longer to offer a reward for killing Wood Pigeons.

Itbon, in collaboration with Mr. J. W. Koenders of the Wildlife Management Department (1963, 1964), investigated the damage done by Wood Pigeons. It appeared that not only the Wood Pigeon population density but also agricultural methods may affect the amount of damage done. The deep sowing of peas may lessen the effect of the Wood Pigeon's depredations. On the other hand, a corner with tardy growth will be used by the Wood Pigeons as a vantage point from where they will spread across and ravage the entire field.

Studies of the habits of Wood Pigeons have yielded information on their rate of reproduction and on mortality due to predators. The impression gained is that the increase in the number of Wood Pigeons is mainly the result of an improved biotope due to new agricultural methods. It is the plentiful supply of food available in early winter rather than the increase in the rate of reprodcution in the summer months compared with mortality that should be regarded as the reason for the increase.

This results in natural food supplies being drawn upon to a lesser extent. Moreover, very early sowing shortens the period in the spring when there is not enough food for the birds. It is too early to say whether it will be possible to create a biotope that is less favourable to Wood Pigeons than the present one; a biotope that would effectively reduce the number of Wood Pigeons in Holland. (Doude van Troostwijk, 1964i.)

## Game mammals

*Red Deer (Cervus elaphus L.)*

Red Deer are found in a comparatively small area only, namely in the wooded and heathery Veluwe region in the province of Guelders. Not until after the Second World War did they become a problem in Holland. This was due partly to the fact that the decline in poaching and other factors caused their numbers greatly to increase and partly to more rational methods in agriculture, horticulture and forestry, on account of which damage to crops and trees was detected earlier and taken more seriously. To protect crops, the Wildlife Management Department of the Ministry of Agriculture and Fisheries decided to fence out most farmlands. But now the forests had to bear the brunt of the damage done by this largest of Dutch mammals. Indeed, the Red Deer studies were undertaken to find out how this problem could be solved. Many foresters wished to see Red Deed disappear entirely from non-fenced areas and to maintain them solely in fenced game reserves. The Government however wanted to maintain this animal in an entirely free state as well.

Red Deer have no natural enemies in Holland that can affect population density, let alone bring about a natural equilibrium. Shooting is therefore the only way to maintain the population at the proper level. The problem was how to maintain a healthy Red Deer population in numbers acceptable to foresters.

This investigation was entrusted to EYGENRAAM and its object was to provide a basis for the policy to be adopted:

1. by making accurate estimates of the number of Red Deer at a given moment on the basis of periodic counts;
2. by finding ways and means of improving the biotope and of reducing to a minimum the damage done;
3. by establishing the maximum permissible Red Deer population density in a certain biotope;
4. by finding out to what extent the damage done is of economic consequence.

1. Accurate information on the Red Deer population density is essential if the latter is to be properly controlled. The gamekeepers' estimates left much to be desired. A method was evolved by which the density could be established accurate to from 5 to 10 per cent. The animals are counted from cars at dusk. The time and place and the direction in which they are moving are set down so as to avoid double counts as much as possible. Recognizable animals are also noted down. The animals are counted on two different occasions. The degree of accuracy is determined by means of the LINCOLN Index on the basis of recognizable animals observed twice or more frequently. Since the Red Deer counts are taken every year, the number of newborn animals and the number of animals shot is known and the number of deaths

due to other causes is also known (the number of dead animals not found is negligible), the counts are becoming progressively more reliable (EIGENRAAM 1964f).

The studies showed that under favourable circumstances the females reach sexual maturity in their second year and give birth to their first fawn in their third year. But only in their fourth year do they become quite independent. A hind is frequently accompanied by a yearling, a two-year-old animal and sometimes even by a three-year-old daughter with her own fawn. These family groups are fairly cohesive, except in the period when the fawns are born and the hind will shoo off the yearlings and older animals accompanying her. It is essential that one should recognize these family groups when counting deer. (EYGENRAAM, 1963j.)

2. Efforts are being made to increase the food available in the Red Deer biotope. Analysis of the contents of the paunch has shown that the diet consists mainly of heather, grass and parts of coniferous trees. In the summer and early autumn the animals eat mainly heather and grass, in the late winter months they mainly eat heather and pine needles and the buds of deciduous trees. They seem to browse on pine needles when grass is no longer available or no longer attractive. Experiments on test fields revealed that they only eat grass when it is lush and that they hardly ever eat certain species at all.

Preference for grassland fertilized with nitrogen.

Intensive grazing prolongs the period of lushness. Species of grass that develop ears late and grow to lushness early in the spring are therefore the best for deer pastures. Nitrogen fertilizers promote the growth of grass and so keep it longer in a state that Red Deer fancy. (EYGENRAAM, 1964c.)

It was found that nitrogen fertilizers would turn certain wild grasses that Red Deer are not very keen on as a rule (e.g. Wavy Hair Grass and Bent) into appetizing food. This does not apply to grasses growing in shady spots such as woods. Experiments carried out with Waldstauden rye were very successful. Fields planted with this kind of grain produced an abundant crop for two years and so plenty of food for the Red Deer.

The damage to trees and shrubs is mainly done in the late winter months and early spring. It was important to find suitable grasses that would be available during this period. In addition, experiments were carried out with an undergrowth of deciduous shrubs, the buds and twigs of which the deer could feed on in the late winter months. It was found that when the food position becomes highly unfavourable for Red Deer as a result of overcrowding (when they do a lot of damage to trees) the hinds and the younger animals accompanying them tend to form herds that stay in one place. This results in still greater damage and a further deterioration in the condition of the hinds and young animals, consequently in greatly increased mortality among fawns.

Trees that Red Deer fancy very much should of course not be planted in a deer reserve unless they are properly protected.

3. The Advisory Committee on Deer Reserves has recommended a density of three Red Deer per 500 acres; the recommendation was based on comparatively scanty data, however. Our studies have shown that this rather small number can be increased under certain circumstances. Improving the Red Deer biotope by providing good pastures, feeding grounds, undergrowth of deciduous shrubs, additional food in winter and by planting trees that Red Deer do not fancy too much make it possible to maintain a density of five Red Deer per 500 acres without too much damage being done.

4. Studies undertaken by PELS RIJCKEN (1965) on the effect of debarking on the Scots pine have shown that, provided the trees are not meant to be sawn into planks, debarking does not affect yield. The bark wounds close again completely in a few years and the trees continue to grow. But debarking adversely affects the quality of sawn timber since it promotes the spread of knots in the wood. Debarking is likely to cause serious damage to other species of trees. At any rate it is important for the forester to know that the Scots pine is not seriously affected by debarking, so that timber from areas under Scots pine exposed to the debarking activities of Red Deer is usable.

Red Deer on feeding place.

*Roe Deer (Capreolus capreolus* L.*)*

In Holland Roe Deer are a trouble to agriculturists, horticulturists and foresters alike, because of the damage they do to fruit trees, osier fields and forests; sportsmen on the other hand are anxious to secure as many bucks with fine antlers as they can. Agriculturists, horticulturists and foresters obviously wish to reduce the numbers of Roe Deer as much as possible and to devise effective repellents to protect crops and timber, but sportsmen like to see Roe Deer multiply and try to improve the quality of the antlers by selective shooting. In addition, holidaymakers like to see Roe Deer about and the nature conservation authorities are proud of this beautiful native Dutch mammal. It became imperative that Roe Deer studies be undertaken, because after the War the animals had greatly increased in numbers and had spread over ever larger areas. They used to live mainly in the eastern, more wooded provinces, but after the War they actually penetrated deeply into the western provinces.

VAN HAAFTEN was asked to carry out the investigations. The first thing to be done was to evolve a method of establishing the Roe Deer population density in the various parts of the country. Our assistant MR. J. PIETERS had the knack of recognizing the footprints of individual Roe Deer. Hoof measurements confirmed that there are individual differences that are visible in the footprints. Whether the method can be used or not depends on the nature of the terrain; it is only successful in places where the Roe Deer leave cover, since in the wood the footprints are of course too vague to be properly judged.

In a number of selected areas information was gathered on the nature of the soil, the vegetation, cover, paunch contents (i.e. composition of diet), chemical composition of the paunch contents and of the flank hair, weight, quality of the antlers and population density.

The studies showed that the quality of the antlers correlates positively with the pH of the soil and negatively with the population density. The specific weight of the antlers correlates solely with the density. In all probability the specific weight of the antlers is a good yardstick for determining whether the Roe Deer population density in a certain area is too great or not.

The studies answered the question why consistently selective shooting had contributed little to the development of fine antlers. Improvement will only result from a drastic reduction of the Roe Deer population density.

If the area is infested with liver fluke parasites *(Fasciola hepatica* L.), good antlers develop at a much later age than they do in areas where this parasite does not occur. Only the older animals build up enough resistance to the liver fluke. As long as they are afflicted with the parasite the animals probably suffer too much to develop strong antlers.

A system was devised (using figures assigned to certain characteristics such as nature of the soil, vegetation, etc.) that enables researchers to establish quickly how many Roe Deer can be allowed in a certain area. It may be regarded as supplementing the method devised by UECKERMANN.

The results show that in many shooting preserves the Roe Deer density is far too high. In those areas a reduction in numbers is therefore not only in the interests of agriculturists, horticulturists and foresters but also of sportsmen. (VAN HAAFTEN, 1965.)

### *Seals*

Comparing the counts taken before 1955 with those Itbon and Rivon (State Institute for Nature Conservation Research) had taken since 1959 showed that the Harbour Seal *(Phoca vitulina* L.) population was then on the decline. The indiscriminate shooting of young seals and the disturbance of their natural environment in the South Holland and Zeeland estuaries by the work on the Delta Project were given as the causes. It was deemed desirable to study the situation; the studies were undertaken by VAN HAAFTEN (1963a) in collaboration with Rivon. This Institute takes regular counts from lighthouses and ships of the fisheries police in the Delta area; Itbon counts both in the Delta area and in the Wadden area, either from ships or aircraft. The aircraft counts in particular afforded a good impression of the seal population density because cameras were used. Moreover, we are trying to

Seal densities are estimated by aerial survey.

band as many young seals as possible to find out to what areas the seals of the Dutch coasts migrate in winter. So far, reports have been received about 13 seals banded in the Wadden area; four came from the German Wadden area and one from the Danish Wadden area.

The remedy adopted, namely total protection until shooting again becomes imperative, would seem to have yielded satisfactory results. In the

Wadden area the number of seals increased from approximately 900 in 1959 to approximately 1,400 in 1964. In the Delta area, however, where the seals' natural environment is unavoidably being disturbed, the numbers decreased still further (from 800 to 300) in the same period.

The Grey Seal *(Halichoerus grypus* L.) is also observed occasionally on the Dutch coasts. But the ones seen are only stray animals from the colony on the Farne Islands (Great Britain) as was evident from the bands on the specimens caught. (VAN HAAFTEN, 1959.)

*Predators (Mustela spec., Putorius putorius* L.*)*

Sportsmen have long taken it for granted that small predatory mammals such as Martens, Stoats, Weasels, Polecats and Foxes and many species of birds of prey do a great deal of damage to game. The Marten and all birds of prey are protected in Holland. Killing Foxes is rewarded because they may transmit rabies. Most gamekeepers wage relentless war on Stoat, Weasel and Polecat. Whether these small predators are really harmful to game, and to what species, is still largely a matter of conjecture.

The fact that game increase in number and that they improve as a rule when a gamekeeper is engaged who relentlessly combats the small predators does not mean much. Better management of the preserve in general will benefit the game. When a good gamekeeper is engaged any improvement will be the result of proper management rather than of the killing of small predatory animals in which gamekeepers are traditionally trained.

The information extent on the subject both in Holland and abroad contained any clues as to whether it was desirable of not to keep small predators in a shoot. That is why we studied the problem.

In an area where for a number of years there had been little shooting and poaching of small game and Foxes, VOÛTE (1946b) observed at the end of the War that Foxes had greatly increased and that Rabbits had declined to a mere fraction of the original number. Hares had multiplied freely, probably because they had to face less competition from Rabbits. Curlews had practically disappeared. When Foxes were again shot in large numbers, the number of Rabbits increased rapidly. It would seem that Foxes can reduce the Rabbit population to a very low density.

On analysing data obtained in dunes in the province of North Holland, DOUDE VAN TROOSTWIJK (1964h) concluded that there was no correlation between the fluctations in the population density of Stoat, Polecat or Weasel on the one hand and of Pheasant on the other. A correlation was found to exist, however, between those of Stoat and Rabbit. The occurrence of myxomatosis was attended by a sharp increase in Polecat population density, which again rapidly decreased when the Rabbit population had been decimated by the disease (see Fig. 1).

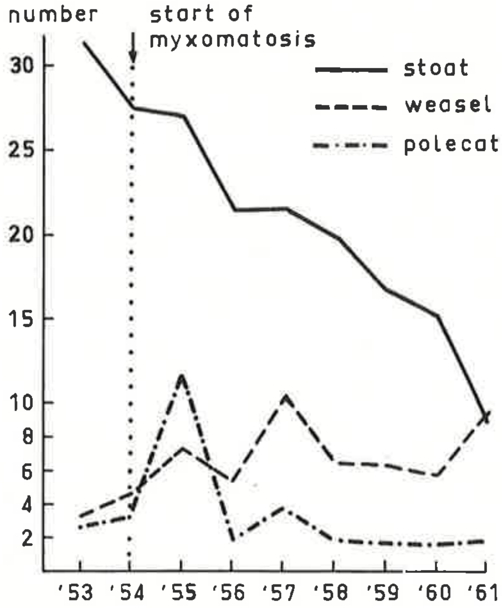



Fig. 1 (DOUDE VAN TROOSTWIJK, 1964h). – Fluctuations in the population density of stoat (ermine), weasel and polecat in dunes in the province of North Holland.

The tentative conclusion is that the occurrence of the Stoat, the Polecat and the Weasel in the area investigated does not affect the number of Pheasants which are abundant in the area and were not bred or introduced there.

## DISEASES

VAN HAAFTEN (1962a, 1960) examines for diseases and parasites in collaboration with the Veterinary Faculty of the State University of Utrecht all the dead game found and sent to Itbon. We hope that this will enable us in due course to obtain a true picture of the distribution of pathogenic organisms carriers in Holland and of how distribution is related to the games' biotope and to the effects of hunting. To discover the latter, VOÛTE (1962) carefully studied 12 shoots. His findings would seem to indicate that myxomatosis persists under moderate hunting pressure, but hardly ever occurs under excessive hunting and disappears when there is very little hunting after first having raged disastrously.

## Repellents

Steensma (Meded. Itbon no. 32, 1957) developed a method of repelling game by means of bone tar. The results were good under certain circumstances. Subsequently, our assistant Mr. J. Pieters suggested using lion dung. Experiments carried out by van Haaften (1963b) yielded favourable results. In both cases the effect of the repellent depends to a large extent on the general food position: when the game are hungry repellents soon cease to be effective. Moreover, the effect of bone tar also depends on how tame the game is.

## Results and prospects of game studies

Plants form new organic matter in spring and throughout the warm season. But production is at a standstill in winter. Consequently, herbivorous birds and mammals will usually have plenty to eat in the warm season. Reproduction takes place in this period. Reserves have to be drawn upon in winter, however, and at the end of the winter there may be a shortage of food for birds and mammals. So if the food supply has the effect of regulating the population density, regulation must be expected to occur at the end of the winter or in the early spring.

The investigations carried out by Itbon would seem to support that theory in a number of cases, as has been shown in the foregoing pages. Analysis of the paunch contents of deer has shown that the quality of the food deteriorates as winter progresses: pine needles take the place of grass. Migratory ducks show a marked increase in population density when their winter biotope improves; the numbers of White-fronted Geese are probably regulated in the late spring or on their spring migrations. The Wood Pigeon population density is largely dependent on the food supply in winter.

Accordingly, particular attention will have to be given to the food position in winter if the game population is to be properly controlled. In addition to supplying extra food, efforts should be made to improve natural food resources, such as providing game pastures under early-flowering grasses, an undergrowth of deciduous shrubs, etc., and taking measures to reduce the population density in the early winter if necessary. We shall have to continue to concentrate on the problem.

Population regulation during the winter months has different implications for the sportsman. As long as the number of animals shot is not large enough for the population density to be reduced to near regulation level, shooting will not greatly affect the population density of the species in question. Shooting may even result in an increase in density, since fewer animals will deplete the winter food supply at the beginning of the winter so that there will be more food for those left. A period of shooting after regulation has taken place will always reduce the population density. The reduction will be reflected in the following year's harvest; it will have dropped by a factor equal to that reduction multiplied by successful reproduction. The spring-time shooting of game doing damage during the winter months may reduce the damage. Shooting migrating game before regulation has taken place is not likely to have any immediate effect.

All this goes to show that knowledge of the regulation mechanisms operating among the various species of game is essential if game is to be properly controlled. Much research will have to be done in this field.

The Black Grouse studies have shown that biotope improvement may sometimes be of importance during the summer months as well. Highly attractive biotopes may lead to immigration and may benefit reproduction. Roe Deer, for instance, though very adaptable, will thrive in park-like country with much cover and much open terrain. It has also been found that in some cases the nature of the biotope strongly affects the damage done by game. The state of the heather, for instance, largely conditions the damage done to apples by Black Grouse.

The occurrence of diseases also depends on the nature of the biotope in some cases. The liver fluke parasite only occurs where there is stagnant water. Marshy land promotes coccidiosis. Shooting, too, plays a part. Where contagious diseases occur intensified hunting is desirable to counteract the spread of such diseases. There are indications that there is a correlation between the amount of hunting that takes place and the occurrence of myxomatosis.

Game repellents are still a difficult problem. In spite of many experiments with chemical and mechanical repellents the 'philosopher's stone' has not yet been found. It is essential that effective repellents become available, especially to protect the woods. Further experiments are therefore called for. How to keep deer away from roads is another similar problem. Itbon has not yet given much attention to the problem. Small mirrors have been used in attempts to solve the problem but the method is still in its infancy.

The studies already undertaken by Itbon have helped to improve game management, and its future studies are expected to yield better solutions to the many problems presented by relatively large numbers of game in a small and densely populated country like Holland with its highly developed agriculture, horticulture and forestry and its heavy road traffic.

Our studies have taught us that the country's scenic features as a whole should be taken into consideration if efficient game management is to be achieved. Changes in the scenic features of one particular area may well influence the position of the game in a much wider area and may even affect shooting conditions and game management in general.

*Chapter 7*

# SOIL BIOLOGY

## INTRODUCTION

Itbon has carried out soil-biology research ever since its establishment. A study of the habits and control of the Pine Sawfly *(Diprion pini* L.) had led scientists to suspect that the soil fauna contained elements that check the mass occurrence of insects. That was why research into soil fauna was placed on the programme. However, the original aim could not be pursued until more was known about the relation of the fauna to its principal source of food, i.e. litter. From the first, therefore, an effort was made to gain a better idea of the part played by fauna in decomposing litter.

After some introductory research by NOORDAM and VAN DER VAART–DE VLIEGER (1943), the work was taken in hand by VAN DER DRIFT and ROOSEBOOM.

The adoption of quantitative trapping techniques revealed that the soil communities were complex and that the composition of the fauna varied greatly, both in location and in season. Observation of various groups of insects in the light of feeding biology showed how important the part was that fauna played in the mechanical destruction of litter. When greater importance began to be attached to the process of litter-breakdown, it became clear that the investigations would have to include microbiology.

The mycological research was undertaken by WITKAMP (and later by NAGEL-DE BOOIS) and the bacteriological research by WENT. The nematodes were also given their own research-worker, MINDERMAN, who turned his attention to analysis of the soil as the environment of soil organisms when the research work was terminated for technical reasons.

VAN RHEE was asked to investigate the effect of earthworms in the soil. BLANKWAARDT studied the effect of biocides on the soil fauna and DE GUNST specialized in the classification of various groups of soil fauna, including enchytraeids (pot worms).

Although originally the investigation was confined to the forest floor, since 1959 it has been extended to cover a number of horticultural problems. The methods developed and knowledge acquired from the work done in the forests have been applied to that in orchards and greenhouses. Our understanding of what happens in the soil has undoubtedly increased as a result. But much research remains to be done before advice of any importance can be given to agriculturalists, horticulturalists and those engaged in forestry. So far, only the earthworm research has progressed far enough to hold out prospects of such advice becoming available in the near future.

## Decomposition of organic matter

As we have said, litter is the principal source of food for fauna and other soil organisms in forest soil. Much study has been devoted to the relation between litter and soil organisms.

Of the experimental fields that have been used for this research in the course of the years, two deserve special mention: a beech forest with a thick layer of litter and humus in the 'Hoge Veluwe' National Park near Hoenderloo, and a deciduous forest with an undisturbed soil profile near Hackfort Castle in the municipality of Warnsveld.

It was in the beech forest that observations were made to obtain a quantitative picture of the insect community in a forest floor (van der Drift, 1951a). The fact that, although it was uniform, its soil horizons were strongly differentiated, made it most suitable for the purpose.

In the experimental forest near Hackfort there are great differences in the decomposition of the litter within a small radius. Part of the forest has a mull soil; i.e. a thin layer of litter that disappears in the course of the year, over a crumbly, loose subsoil with many litter fragments. This type is found in both a calcareous and an acid form. Another part is covered with a mor soil, i.e., a thick layer of undecomposed litter, which gradually makes way for a black humus-layer. The dividing line between it and the leached subsoil below it is fairly sharp on the whole. Besides these two main types, intermediate types are found (see Fig. 1). The vegetation consists of oak, birch, poplar and alder. However, these sorts are mixed in different proportions in the various parts of the experimental field (see Fig. 2).

The primary causes of mull and mor formation are found to lie in the characteristics of the soil and the water regime (Minderman, 1960). They determine the vegetation, which in turn determines both the nature of the litter and the microclimate in the litter layer, and with them the quantitative and qualitative composition of the soil organisms (Witkamp and van der Drift, 1961).

As regards our Hackfort experimental field, the difference in the faunistic composition of mull and mor is attributed to the following differences between these soil types (van der Drift, 1961a):

Fig. 1

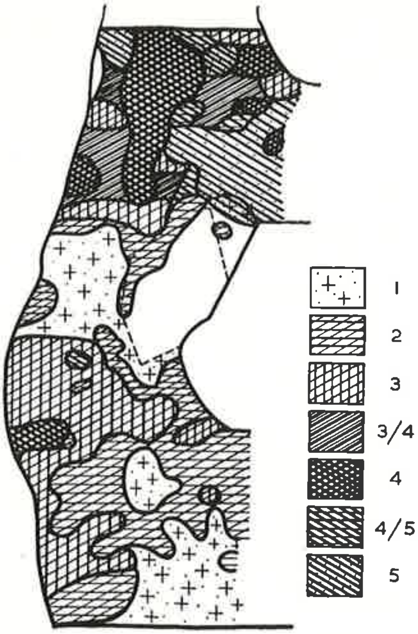



Fig. 2

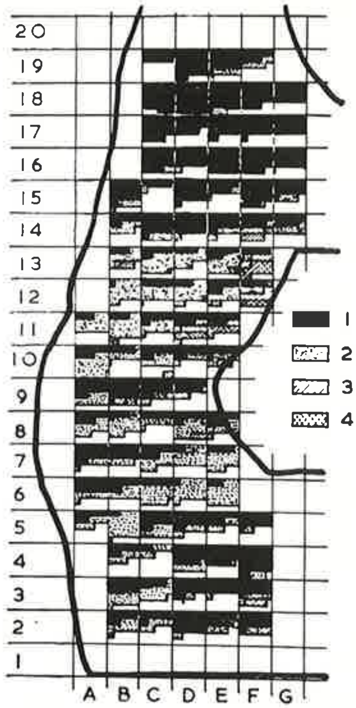



Fig. 1 (MINDERMAN, 1960). – The distribution of forest-floor subtypes from field records. 1 = common mull, 2 = mull rich in litter, 3 = light mor, 4 = common mor, 5 = mor poor in humus. Transitions are indicated by 1/2, 4/5, etc.

Fig. 2 (MINDERMAN, 1960). – The volume of wood of oak, birch, poplar, and alder found on the various quadrats. The volume for each species on each quadrat is expressed as a percentage of the maximum volume which occurs on any quadrat i.e. 3000 cub. dm on quadrat D18 = 100%. Thus quadrat F12 has only 80% of the maximum observed volume on D18 and 16% is oak, 18% is birch, 26% is poplar and 20% is alder. 1 = oak, 2 = birch, 3 = poplar, 4 = alder.

1. The relative humidity is from 5% to 10% higher in the mull than in the mor, owing to its being more thickly covered with trees and herbage.
2. In spring the litter layer in the mull dries out considerably less than that in the mor. The reason is that mull is protected by birches and poplars, whose leaves open early, whereas the mor has only oaks to protect it, and oak leaves open much later.
3. The mull contains a far higher percentage of 'shade' leaves of oaks than does the mor. This is probably due to its being shaded by the taller birches, poplars and alders while the oak leaves are budding. One of the features of shade leaves is their thinness. The saprophagous soil fauna greatly prefer shade leaves to the sun leaves which predominate in the mor type.

4. Since the litter from alder, birch, hazel and poplar is preferred to that from oak, the food for soil fauna in the mull type is better than that in the mor, which consists solely of oak.
5. The lime in the calcareous type of mull enables a number of species to flourish there, which elsewhere are found only in pronouncedly calcareous regions.

Tests were carried out to discover how quickly the litter in the mull and the mor parts of the field decomposed. They showed that the decomposition of litter was greatly dependent on the weather. In average climatic conditions the litter in mull is reduced to a single leaf layer by early summer, and within about six months the entire litter production of the previous year has disappeared. Under the same conditions the same quantity of litter in the mor-part takes a whole year to disappear (see Fig. 3). In unfavourable climatic

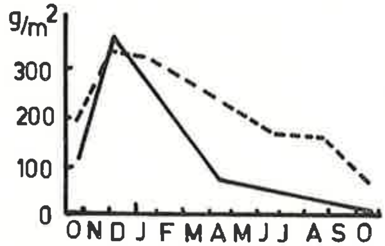



Fig. 3. (WITKAMP a. VAN DER DRIFT, 1961). – Amount of litter on a cleaned surface in mull and mor. (O = October, N = November, etc.)

conditions (dry, cold weather) the litter in the mull takes longer to disappear. Only if the weather is extremely bad is there any litter left at the end of the season. In the mor type a spell of weather that is below average will result in an accumulation of litter, and a spell of weather that is better than average will cause a reduction in the litter layer (see Fig. 4). The variations in litter decomposition under various climatic conditions is entirely due to the influence of the weather on the activity of soil organisms (VAN DER DRIFT, 1962b).

The activity of the micro-organisms that decompose cellulose was also measured by means of slides covered with a film of cellulose. The time it took for the film to disappear was taken as the standard for that activity. Table 1 (WENT, 1959) shows that the activity varies greatly in the various types of forest.

*Table 1* – NUMBER OF WEEKS NECESSARY FOR THE DISAPPEARANCE OF CELLOPHANE IN DIFFERENT FOREST-SOIL TYPES.

| Oak forest | Condition of the soil | pH (KCl) | pH (water) | Weeks |
|---|---|---|---|---|
| Hackfort | calcareous mull | 5.2 | 5.9 | 12–23 |
| Hackfort | acid mull | 3.4 | 4.3 | 26–39 |
| Hackfort | mor | 3.0 | 4.1 | 20–45 |
| Middachten | acid mor | 2.8 | 4.1 | 7–10 |

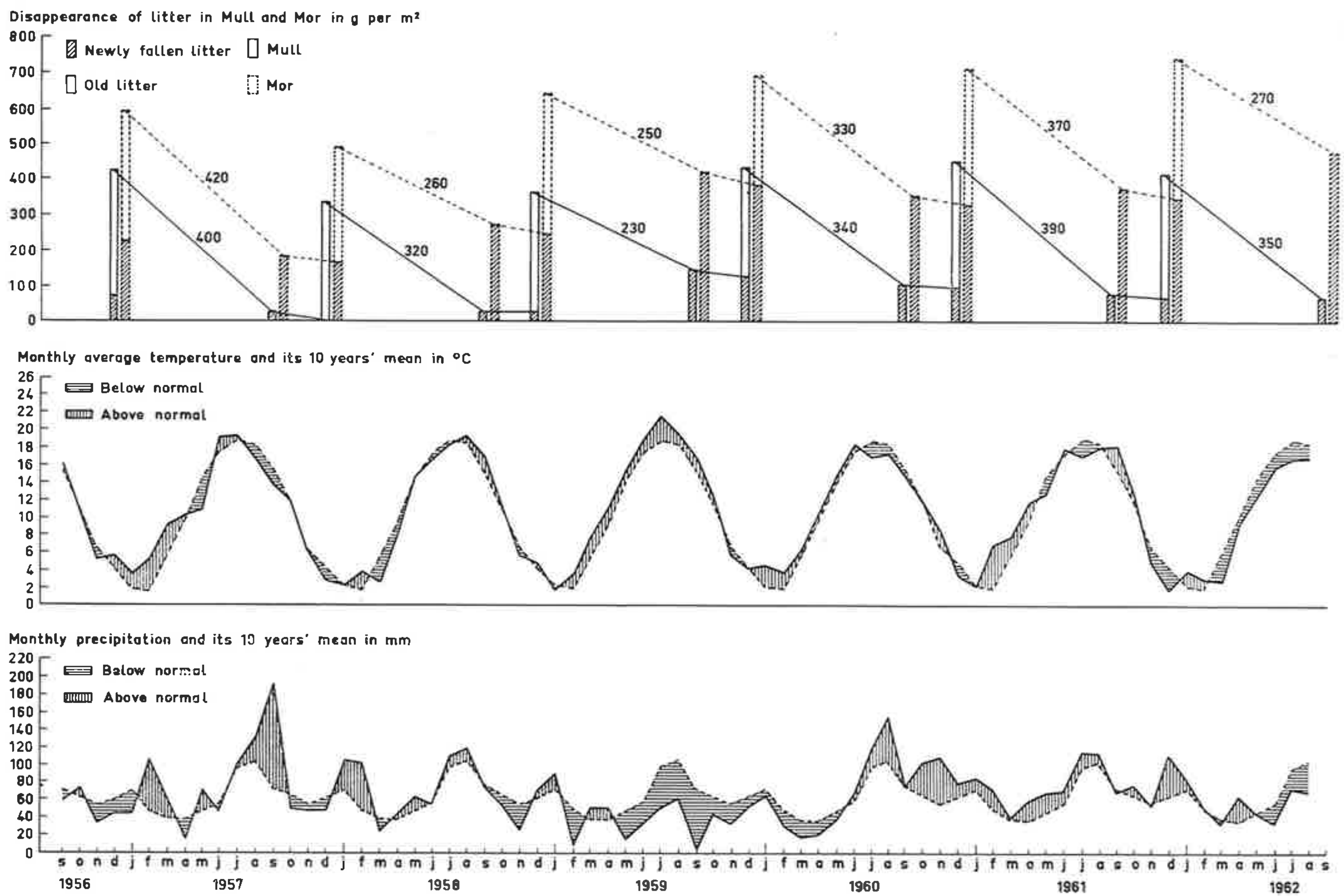



Fig. 4 (VAN DER DRIFT, 1962b). – Disappearance of litter in different years.

Many of the cellulose-decomposing fungi were isolated. A number of them grew fanwise on the slides, the cellulose decomposition taking place under the fans. In very many fungi decomposition only took place there, but in *Trichoderma* the cellulose disappeared not only under the fans but also under the normal hyphae.

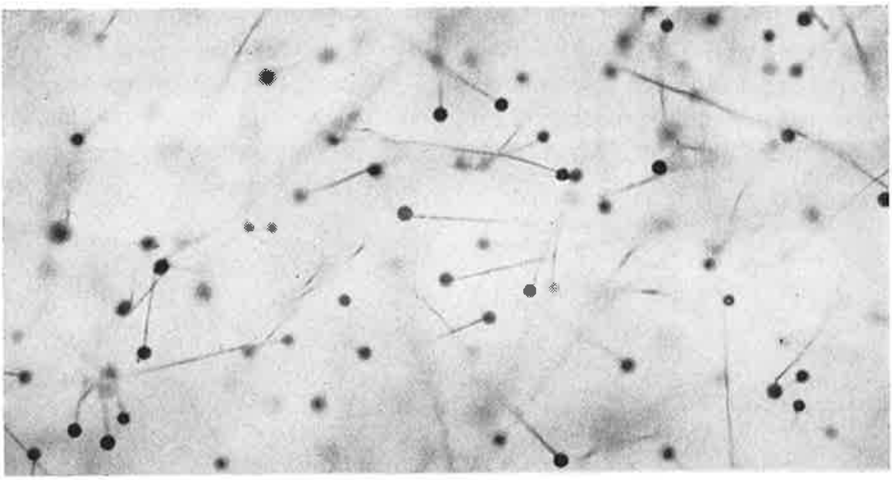
Cellophane recovered from the mor of an oak forest, showing attack by fungi (hyphe and fanlike growth), a myxobacterium and snails or slugs.

Our research confirmed once more the well-know fact that mull soil is rich in bacteria, and mor in fungi. Counts confirmed the great differences in the number of bacteria. But how far the small number of hyphae in the mull field can be regarded as an indication that those species are rarer because the dead hyphae last longer in mor than in mull, where they are attacked by bacteria, is an unsolved problem. Oak leaves from mull proved richer in fungi species than oak leaves from mor (WITKAMP, 1960).

Fungi and bacteria greatly affect one another. To discover how they interacted, WITKAMP and STARKEY (1956) in the United States worked out a method of detecting antibiotics.

They were able to demonstrate that certain fungi had an antibiotic affect on certain bacteria. Fungi concentrations can hinder the development of micro-organisms. It seems that, in some cases at least, the antibiotics are deposited only on the spot where the mould grows. In soil that is rich in bacteria, the bacteria can attack and decompose fully-developed hyphae. Such soil can be expected to contain fewer hyphae. It was indeed possible to demonstrate that fungi grow properly in the mull type, though less rapidly than in the mor type.

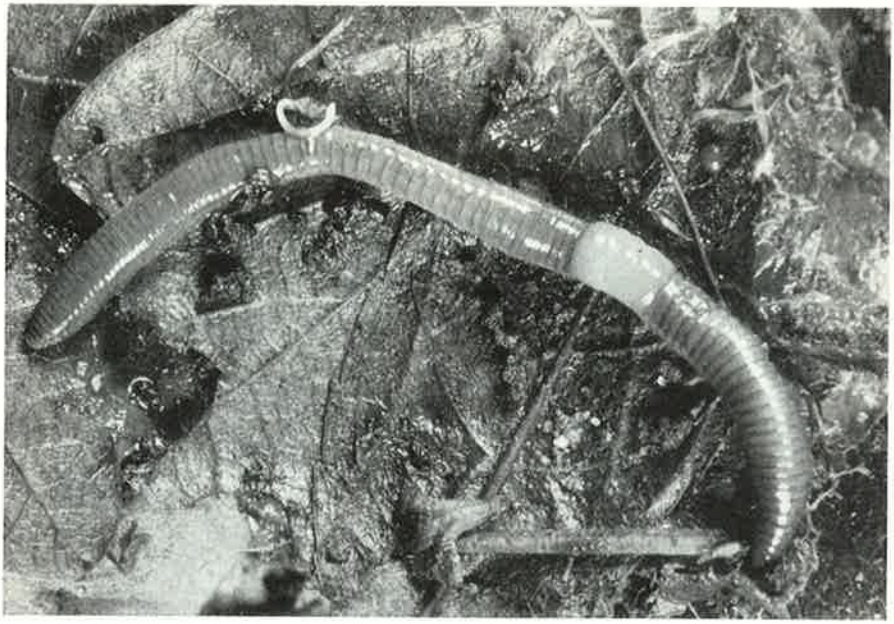
At the same time actinomycetes and bacteria were found to be capable of impeding or checking the germination of fungal spores (fungistasis). Observations in Hackfort proved that in the calcareous mull region the germination of the spores of the test-fungi *Trichoderma viride* and *Penicillium nigricans* had been brought to a complete standstill, that in the mor it was only very slightly delayed, and that in the acid mull region it was about average. The germination of *Mortierella rammaniana* spores was halted only in the mull region. In the mor, many *Mucorineae* (the family to which the abovementioned fungus belongs) are found growing in profusion, but a certain number are found in the other regions, too.



Sporangia of *Mucor rammanianus* MÖLLER (100× natural size).

To gain a better understanding of the way in which litter is broken down, endeavours have been made to follow closely the fortunes of a fallen leaf.

A newly-fallen leaf is quickly invaded by a number of organisms: Rotifera, Tardigrada, Acari, Algae and Fungi. The longer the leaf lies on the ground the greater the number of moulds (WITKAMP, 1960). After a time (how long depends on the kind of leaf and on the weather) the leaf may by attacked



Fragmentation of leaves, and excrements of *Lumbricus rubellus* in litter.

Fly larvae *(Bibio* sp.) on oak litter.

by various species of litter-inhabiting animals. They reduce the amount of material, but they effect only a very slight degree of chemical conversion.

Many animal species (for example, the pill-millipede *Glomeris marginata)* retain the material in the intestine for from 3 to 5 hours only – a very short time in which to develop effective intestinal microflora. The earthworm retains food in its intestine for from 16 to 48 hours (VAN DER DRIFT, 1958a), and even then large residues of undigested food are found in the feaces. The earthworm possesses an intestinal microflora; the extent to which that flora differs from that of the litter itself must be left undecided. In most of the larger species of soil fauna the difference between the dry weight of the ingested leaf and that of the faeces – in which, as we have said, much of the leaf remains unchanged – is slight. Only a small part is actually consumed. It was shown that a small food intake in the snail *Zenobiella incarnata* and in a few other species is accompanied by relatively larger food retention. This may be a consequence of the fact that the material remains in the intestine, exposed to the action of the enzymes that bring about digestion, for a longer period. So it cannot always be said that the food ingested in smaller quantities is less suitable. When the same food (for instance, oak leaves only) was continuously given, both consumption and retention deminished.

After a time, the fallen leaf, if not attacked by fauna, is infested with and attacked by hyphae and bacteria. This is apparent, not only from microscopial examination of leaves that have been rendered transparent – a technique evolved by MINDERMAN (1956b) – but also from the fact that in litter respiration takes place, which can be determined by measuring the $CO_2$ produced. The fungi and bacteria are consumed by the fauna together with the remains of the leaves, and are probably an important constituent of the actual food material.

Earthworms' food is a mixture of organic and inorganic material. Their excrement does not contain more bacteria than might be expected in view of the mixing in the intestine of the organic litter material, which is rich in bacteria, with the soil, which is not. There were indications that soil containing worms was richer in bacteria than soil devoid of worms (WENT, s. Annual Report 1961). But this greater richness is not so much a consequence of the development of the worms' intestinal microflora as of the worms' activities that improve conditions for bacteria (digging, mixing, and transporting and attacking organic matter).

The extent to which the mechanical destruction of litter by an animal can promote conversion came to light when studying the part played by larvae of the caddis fly *Enoicyla pusilla* BURM. (VAN DER DRIFT a. WITKAMP, 1960). The larvae used for their metabolism only a small part of the consumed

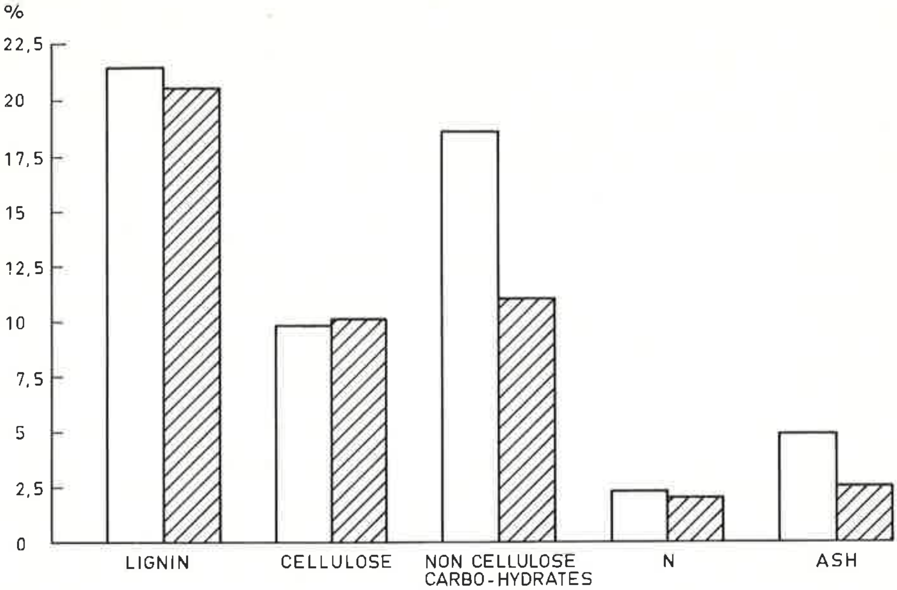



Fig. 5 (VAN DER DRIFT a. WITKAMP, 1960). – Chemical constituents of oak leaves in % oven-dry (white columns) and faecal pellets (hatched columns).

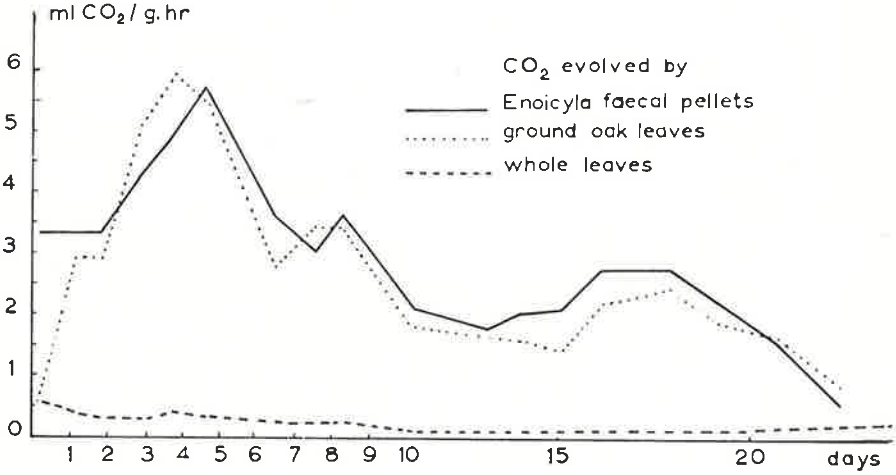



Fig. 6 (VAN DER DRIFT a. WITKAMP, 1960). – Evolution of $CO_2$ from 1 g oak leaf material in Conway units at 25°C (water was added after 1 and 2 weeks).

leaves – in the main, easily soluble carbohydrates (see Fig. 5). The rest found its way into the faeses in the form of minute leaf-fragments. The numbers of bacteria and fungi that could be isolated from the excrements – which had a higher pH than the leaves – were 8,500 times and 50 times as high as those from the leaves respectively. This enrichment was also evident from the increase in carbon dioxide produced by the faeces; it was 7 times as high as that of the intact leaf. An equally marked increase occurred when the leaf was artificially reduced to fragments of the same dimensions as those in the faeculae (see Fig. 6). What happens to the excrements after that largely again depends on animal activity. If there is great activity as in the mull type the pellets are very soon ingested by large saprophagous animals. If there is slight activity (mor type), they may still be traceable many months later.

Examination of the biomass of the various species of animals considered as belonging to the soil fauna would lead one to assume that it is worms, and perhaps slugs, that have the greatest effect on the conversion of litter (see VAN DER DRIFT, 1951a). Nevertheless, it is worth while giving attention also to small species such as nematodes, many of which occur in very large numbers. They were studied and an effective mode of inventarization was worked out, one which is far less time-consuming than the old methods (MINDERMAN, 1956b). The investigation was suspended when it was discovered that for a proper understanding of the activity of nematodes it would be necessary to know far more about the soil itself and about the life of the bacteria it contained.

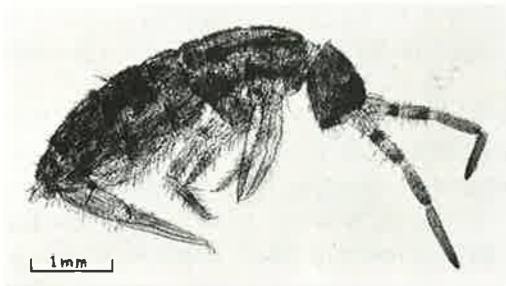
The investigation revealed that almost all the fallen leaves and twigs in litter are reduced by fauna. Bacteria and fungi develop in the faeces and the resulting mass constitutes a source of food for certain fauna elements, whose excrements are once again attacked by bacteria. So it can be said that in the decomposition of litter there is very pronounced interaction between fauna, fungi and bacteria, the litter traversing the animals' intestines several times and different groups of microbes and fungi being broken down each time.

It is evident from the foregoing that, contrary to what is frequently stated in forestry literature, fauna alone cannot be expected to form stable humus. The actual chemical decomposition of the leaf is brought about almost exclusively by the agency of bacteria and fungi.

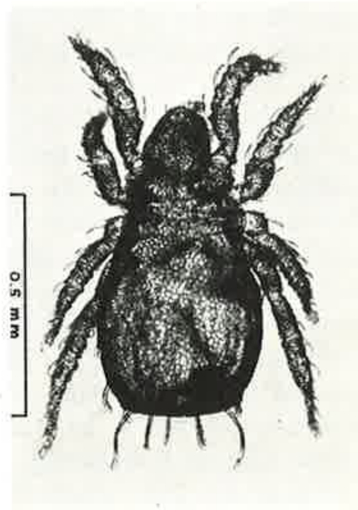
## PROFILE-DEVELOPMENT

With a view to obtaining a general impression of the part played by fauna in developing the soil profile, VAN DER DRIFT (1964) studied the composition of fauna feeding on decaying matter and what happened to their excrement in the profile of five types of vegetation on an inland dune.

In the bare sand no saprophagous fauna was found. In the moss-patches the principal inhabitants were collemboles, i.e. springtails (chiefly *Isotoma sensibilis)*. Their droppings were found to a depth of 4 cm, and they themselves to 2 cm. In the grass vegetation besides the springtails and mites there were enchytraeids, and excrements were found to a depth of 6 cm. All the groups were far more numerous under heather and under pine trees and excrements were found to depths of 8 and sometimes over 10 cm.




Springtail *Orchesella cincta* (LINNÉ) 1758.




Moss-mite *Nothrus silvestris* NICOLET, 1855.

Soil organisms take part in profile-forming by:

1. mixing the mineral subsoil with litter, and mixing the material of the various layers of soil,
2. affecting its structure,
3. concentrating certain materials in certain places.

1. Various species of earthworms which play a part in the mixing of soil layers have been included in the investigations. They have been studied both in the field and in the laboratory.

It was found that grassland in particular offers earthworms a good means of subsistence. If grassland contains no earthworms, a superficial layer of undecomposed litter is formed, similar to the mor that is formed in forests. When earthworms were put into small artificial profiles in the laboratory, superficial leaf matter disappeared after a few weeks (VAN RHEE, 1963a). A similar process, though slower and sporadic, was observed in the field after a large number of earthworms had been put into grassland. Both in the laboratory and in the field the worms worked much of the litter into the mineral subsoil through their intestines. In this manner they brought about the mixing of dead plant parts with mineral soil.

Other soil animals play a much smaller role in that respect.

2. A good example of soil fauna affecting soil structure may be seen in the excellent spongy structure underlying the topsoil of many old fluvial clay soils. In many instances it owes its existence to the activity of the tiny aquatic worm called *Tubifex*, during the period in which sedimentation took place (Doeksen a. Minderman, 1963).

In the upper stratum various species help to enhance the perosity of the soil. The enchytraeids may be important in this respect; that is why they have been included in the research. Steps were taken to determine what species occur in the Netherlands (de Gunst, 1965) and their behaviour in the soil. As they occur in great numbers, the fine network of passages they make certainly affects the structure of the soil. The investigation is still passing through its initial stages.

In the laboratory it was found that earthworms, too, improve the soil structure. There were indications that the formation of a crumbly structure is furthered by their presence. Observations in the field supported the theory,

Tunnel formation by *Allolobophora longa* in an artificifal profile with litter rests on top.

but furnished no conclusive evidence (van Rhee and Nathans, 1961a), for when many worms are found in soil with a good structure it is not easy to ascertain whether the good structure is due to the presence of the worms, or whether worms flourish in soil with a good structure. Both explanations are probably correct up to a point.

3. The soil fauna may not only promote the mixing of the various layers of the soil but also tend to concentrate certain of its constituents. The latter process takes place when the faeces are deposited together in groups. Such material often constitutes the point where certain bacteria attack.

## Predacity

The soil fauna includes many predators. Some of them live in the litter and some move about on or over the soil. Hibernating insects in particular may fall victim to them the moment they go in search of hiding places in the soil.

Pitfall traps are used to determine the composition of the surface fauna. The catches do not automatically give us an idea of the density of the species. The figures for the numbers caught take into account the kind of specific mobility, the seasonally varying activity and the density.

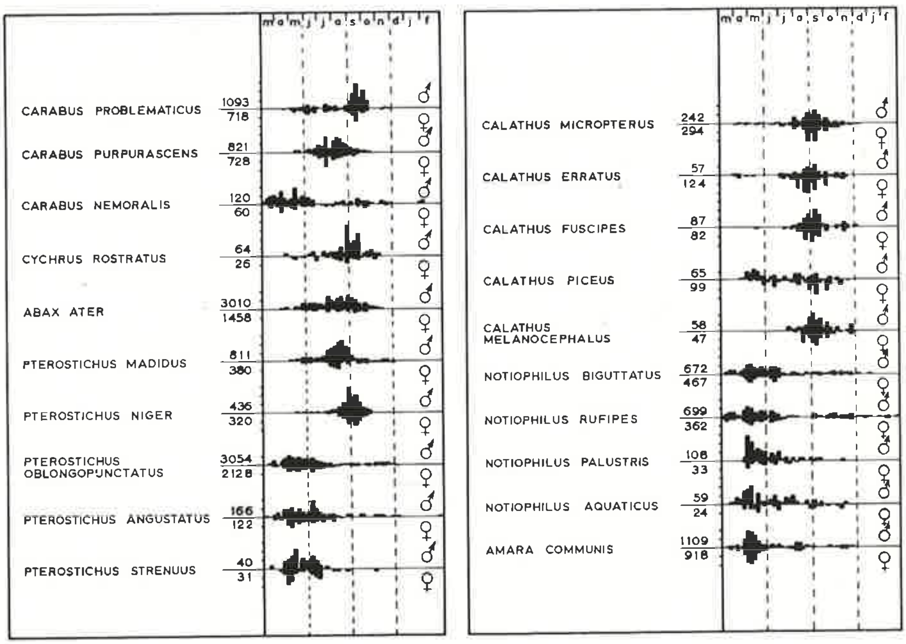



Fig. 7 (van der Drift, 1959a). – Average activogram of the main forest carabids.

*Table 2* – TOTAL CATCHES IN 20 PITFALL TRAPS IN DIFFERENT TYPES OF TERRAIN AT DIFFERENT TIMES OF DAY FROM JULI 29TH – AUGUST 2ND, 1957.

| | A. Arranged according to type of terrain | | | | B. Arranged according to time of catches | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Grass | Heather | Birch wood | Scots pine wood | 7–9 | 9–11 | 11–13 | 13–15 | 15–17 | 17–19 | 19–21 | 21–23 | 23–1 | 1–3 | 3–5 | 5–7 | 7–9 |
| *Carabus purpurascens* F. | 7 | 6 | 19 | 35 | 3 | | | | | | 6 | 18 | 15 | 18 | 3 | 3 | 3 |
| *Abax ater* VILLA | 18 | 7 | 13 | 15 | 1 | | 1 | 1 | 1 | 3 | 5 | 11 | 8 | 15 | 2 | 5 | 1 |
| *Pterostichus madidus* F. | 34 | 8 | — | — | 2 | 5 | 3 | 8 | 9 | 7 | 9 | 1 | | | | 1 | 2 |
| *Poecilus coerulescens* L. | 29 | 3 | — | — | 3 | 8 | 7 | 11 | 6 | | | | | | | | 3 |
| *Calatus erratus* SAHLB. | 1 | 25 | 2 | — | 1 | | | | | | 1 | 4 | 6 | | 7 | 8 | 1 |
| *Calatus melanocephalus* L. | 4 | 7 | — | — | 2 | | | 1 | 2 | 2 | | | 1 | 1 | 1 | 1 | 2 |
| *Staphylinus olens* MÜLL. | — | — | 10 | 3 | | | | | | | 1 | 4 | 3 | 4 | | 1 | |
| *Philonthus* sp. | 63 | 2 | 7 | 3 | 5 | 17 | 20 | 22 | 8 | 6 | 2 | 3 | 1 | 1 | 2 | 1 | 5 |
| *Silpha carinata* HERBST imm. | 26 | 5 | 1 | 2 | 6 | | 1 | 3 | 8 | 7 | 3 | 3 | | | | 1 | 6 |
| *Silpha carinata* HERBST larv. | 25 | — | — | 5 | 4 | 1 | 1 | 11 | 6 | 5 | 2 | 1 | | | | | 4 |
| *Geotrupes stercorosus* SCRIBA | 28 | 13 | 21 | 108 | 26 | 25 | 16 | 31 | 34 | 28 | 9 | 1 | | | | | 26 |
| *Geotrupes vernalis* L. | 10 | 8 | 5 | 3 | | 5 | 13 | 2 | 6 | | | | | | | | |
| *Myrmica ruginodis* NYL. | 93 | 139 | 132 | 42 | 47 | 40 | 24 | 22 | 21 | 15 | 5 | 9 | 14 | 11 | 10 | 14 | 47 |
| *Lasius niger* L. | 106 | 15 | 1 | 6 | 6 | 28 | 29 | 22 | 12 | 8 | 0 | 0 | 3 | 0 | 2 | 3 | 6 |
| *Collembola* | 184 | 13 | 25 | 186 | 67 | 57 | 25 | 46 | 23 | 6 | 14 | 27 | 16 | 32 | 45 | 63 | 67 |
| Various small spiders | 61 | 7 | 13 | 38 | 21 | 18 | 11 | 13 | 7 | 7 | 4 | 6 | 8 | 8 | 13 | 14 | 21 |
| *Lycosidae* | 33 | 20 | 13 | 23 | 8 | 9 | 3 | 14 | 11 | 12 | 4 | 2 | 7 | 6 | 3 | 11 | 8 |
| *Opiliones* | 4 | 4 | 5 | 7 | | 1 | 1 | 5 | 3 | | 1 | 3 | 2 | 1 | | 2 | |

Berlese devices were employed to determine the actual density of smaller species. For the larger species of beetles the Lincoln Index was used, marked beetles being released and recaught. A reasonably accurate estimate was made of the total density of the beetle population by relating the number of beetles recaught to that of the unmarked beetles caught.

Inventarization of the soil fauna showed that the surface-fauna included a number of species that might be expected to differ little in their manner of feeding. It was found that some of the species exhibited great differences during the period of the year in which they were active (see Fig. 7). There are species with one or with more periods of activity per year, and even species that are active all the year round, though a period of frost naturally checks their activity.

Their activity is of course restricted to certain hours of the day. Some animals are active at night, others in the day-time. Clearly, day-rhythm and seasonal rhythm are paramount in determining the importance of an animal as a predator.

Obviously the type of field determines to a large extent the qualitative and quantitative composition of the surface fauna. Table 2 (van der Drift, 1959a) illustrates this. Within a certain field, certain distribution patterns were observed, which remained distinguishable for a number of years under varying population densities (van der Drift, 1959a).

Ants were found to drive out predatory beetles. There were noticeably few beetles around the nests of red wood-ants.

## Biocides in the soil

The increasing use in the soil of biocides and the treatment therewith of plant parts above ground, during which some of the substances fall to the ground, makes it essential to study the effect such substances have on soil organisms.

Biocides may accumulate in the upper layers of the soil, where most of the fauna and other organisms live. Most fungicides and herbicides are soon rendered inactive by the action of bacteria. The same thing applies to many insecticides. They may also be absorbed by soil particles or chemically converted. The chlorinated hydrocarbons, however, are extremely persistent in the soil, so that further accumulation can occur after each application thereof.

Research into the effect of weed-killers in a wood revealed that the soil fauna increased as a result of the temporary accumulation of litter from the large quantity of plants killed. Damage to soil organisms was not observed.

The degree of activity exhibited by the soil fauna and especially their size

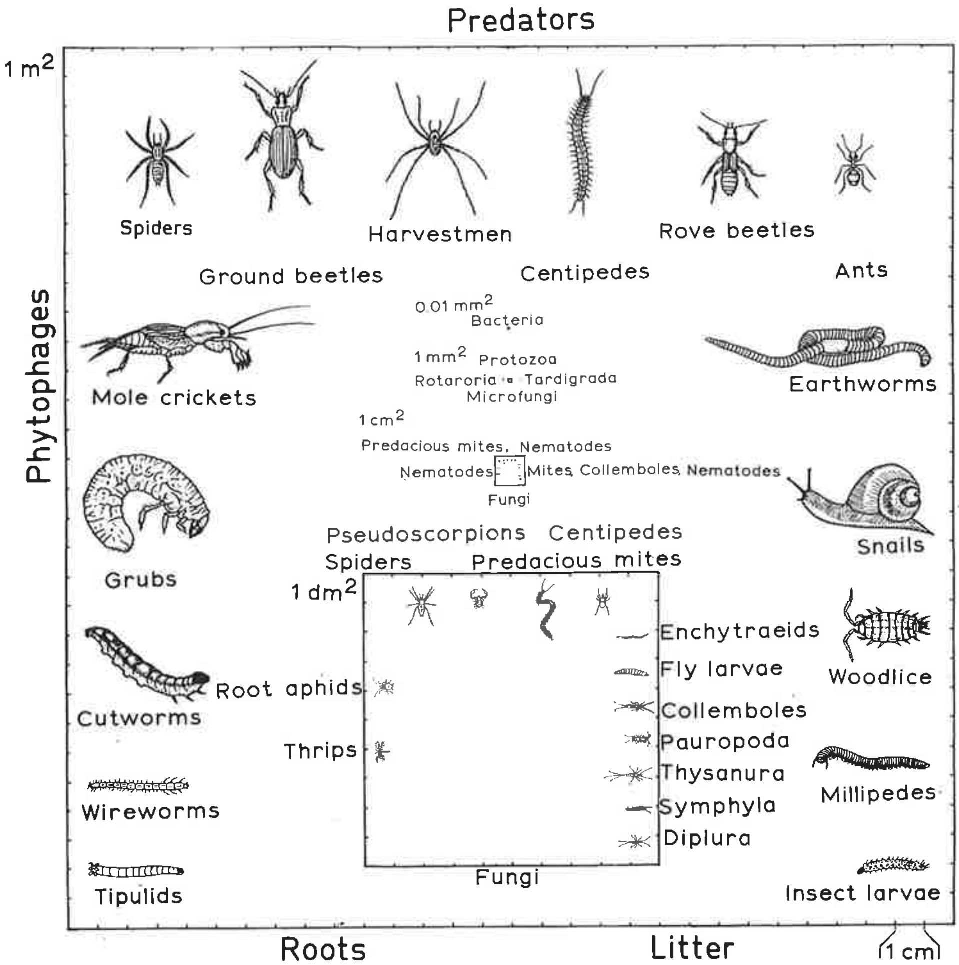



Fig. 8 (VAN DER DRIFT, 1963d). – The diagram indicates the areas to which the density of the soil organisms of different size categories must be related in order to give a meaningful comparison, this in relation to the chance of contact with a certain amount of particles of insectides. The biggest square represents an area of 1 m² to which is related the density of the macrofauna varying in lenght from 1 to 10 cm.
The smaller squares represent respectively 1 dm² for the fauna varying in length from 1–10 mm and the macrofungi, 1 cm² for the mesofauna from 100–1000$\mu$ and the mesofungi, 1 mm² for the microfauna from 10 to 100 $\mu$ and 0,10 mm² for the bacteria. In each square we find on the left side some representatives of the phytophagous species, on the right side the saprophagous species, on the top the predatory species and on the bottom the fungi and bacteria. At the foot of the diagram we find the basic food of the soil organisms that consists of roots and litter.

($10\mu$–10 cm) affect the risk they run of coming into contact with poison particles and the likelihood of their avoiding poison (see Fig. 8). As a rule, the smaller the animal, the smaller its living-space and the greater the likelihood that its living-space will escape being poisoned. Consequently, of any group of animals equally susceptible to an insecticide, the larger and the more mobile ones are more likely to be affected than the smaller ones. (VAN DER DRIFT 1963d.)

In order to test the effect of biocides on the soil fauna, individuals of various species were sprayed with insecticides, and other individuals of the same species were placed in soil treated with insecticides. Individual specimens of the same species were seen to react very differently, and in many cases it was weeks before the animals died (see table VAN DER DRIFT, 1963d).

Laboratory tests of this kind are a good means of gaining an impression of susceptibility, but they do not indicate what can be expected in the field. A distinction must be made between insecticides put into the ground to kill certain soil organisms and insecticides that have found their way into the soil through the spraying of plant parts above ground. In the case of the former, of course, the risk to the soil organisms is far greater. But even the second method of application is not without danger. When an orchard is sprayed, insecticides accumulate in the upper soil layers. So they can be expected to affect the animals living in those layers. The small number of ground beetles found in orchards is probably partly due to the fact that there are always persistent insecticides present in the upper layers of the soil.

Field tests in which orchard conditions were imitated showed not only that DNOC, Parathion, Karathane and TNTD affect earthworms very differently but also that the conditions under which and the time of year at which the treatment is carried out greatly affect worm mortality. After a test-spraying with DNOC in wet weather in spring only dead worms were found, whereas the same spraying in dry weather in July resulted in no mortality whatever (VAN DER DRIFT, 1963d). This is undoubtedly due to the worms' reduced activity during dry spells. Animals are in the greatest peril immediately after spraying, as many insecticides disintegrate quickly. If worms are inactive during the treatment they do not come into contact with the poison, particularly in periods of drought, when most worms withdraw to somewhat deeper layers.

On comparing the quantities of insecticide caught in funnels just above ground level when spraying and when atomizing, it was found that from 7% to 13% of the quantity applied (2,000 to 2,500 litre/hectare) fell to the ground after spraying, as against a mere 2% to 4% (200 l/ha) after atomizing. Sampling the soil in an old orchard, where the former method had always been used, clearly revealed the effect of uneven distribution of the liquid.

With the exception of centipedes and oribatids (horn mites), soil fauna were more numerous in open spaces (where relatively little spraying-liquid, if any, falls) than under the trees.

Soil sterilization in glasshouses was found to have a very pronounced effect on earthworms (BLANKWAARDT a. VAN DER DRIFT, 1961). Steaming and treating with chloropicrin killed practically all the worms but did not exterminate them, since not all the cocoons were killed and some worms migrated to the spot from the subsoil and some moved horizontally from neighbouring untreated areas.

Sterilizing with chloropicrin was found to affect the bacterial flora of the soil, but the matter has not yet been dealt with. Examination by the modified LOCKHEAD method showed a reduction in the numbers of bacteria needing growth-promoting substances for their development.

## EARTHWORMS IN ORCHARDS

On examining a number of soil-treatment trial plots, it was found that earthworms only developed properly where there was turf: from 300 to 450 worms per sq. m. were found underneath the grass as against from 25 to 125 in orchards without grass. Short grass was found to be better for worms than long grass. Spraying with water had no noticeable effect. The large species, *Lumbricus terrestris* and *Allolobophora longa*, reacted less to soil treatment than did the small species. The soil structure underneath grass was found to be better than that under earth without grass. Whether this was a consequence of the worms' activity or was caused by the grass itself could not be determined, because there were no grass-plots without worms.

It should be noted that in laboratory tests worms undoubtedly improved the structure.

Research carried out in a number of orchards into the periodical population-density fluctuations connected with the development of the worms showed that the fluctuations were due to the sexually immature worms. The number of sexually mature worms did not vary much on the whole. Breeding experiments in the laboratory in various densities showed that when the density was increased their growth retarded and fewer became sexually mature. When groups of 20, 40 and 80 young *Allolobophora caliginosa* were bred in 2 kg of soil with abundant food, the final weights after 3 months were 148, 94 and 80% of the respective original weights; 80, 41 and 19% respectively had tuberculae pubertatis, and 47, 8 and 2% had a clitellum (Annual Report 1964).

In standard tree orchards and plantations of bushes the number of worms was seen to be lower in the first category, which was sprayed, than in the other, which was atomized with insecticide, the averages being $50/m^2$ as against $232/m^2$. Atomizing is thought to be less harmful to earthworms, and probably to other elements of the soil fauna, too, than spraying.

## Black peat

In co-operation with other institutes we studied the soil-biological qualities of black peat as an organic fertilizer. This substance, which is dug in large quantities, is exceedingly stable. If allowed to dry, it becomes peat, which does not easily absorb water and cannot be used for agricultural purposes. However, if the substance freezes before it dries it becomes highly absorbent and can be used in agriculture as a substitute for peat dust, being called 'garden peat'. The question we had to answer was to what extent garden peat could enhance life in the soil.

The addition of ammonia to black peat is known to generate heat. Tests showed that heat is generated not as the result of metabolic activity on the part of certain bacteria but by a chemical reaction between black peat and ammonia.

Experiments have been carried out to discover how fauna develop in garden peat mixed with household and garden refuse. When the heat subsided – i.e. about 3 months after the compost heaps had been made – fauna began to develop in the household refuse and in the mixtures of household refuse and garden peat. The latter had a far larger proportion of predatory mites *(Gamasidae)*, certain springtails *(Isotomidae)* and enchytraeids.

Laboratory tests were carried out to discover the extent to which black peat, frozen black peat and 'bolster' (i.e. the as yet scarcely decomposed 'white peat' lying on the surface) were populated from compost, garden soil and garden peat, which had been kept on the soil for a long period. To this end 'rearing cells', 9 cm $\times$ 4 cm and $1^1/_2$ mm deep, were half filled with the 'inculation' material and half with black peat, frozen black peat and 'bolster'.

All the latter sustrata were inhabited by a large population of *Isotoma notabilis* from compost. After a few months the number dropped to a lower level, at which they held their own. In the frozen black peat there developed a small population of the springtail *Tullbergia* from compost; a considerable *Tullbergia* population penetrated all the substrata from garden soil.

Only one species can hold its own with garden peat as its sole source of food, namely an enchytraeid called *Cognettia sphagnetorum*, isolated out of the humus of Scots pine.

The results of experiments indicated that there are indeed ways of enriching animal life, and probably bacterial life, too, with garden peat. It should be pointed out that investigations by other institutes showed that black peat could indeed enhance the fertility of the soil.

### Compost heaps

Research has been done to discover the nature of the population of compost heaps formed of beech litter and garden and household refuse. In beech compost the fauna from beech litter held its own for a long time, with the exception of the species that only inhabited it during the larval stage. A few saprophagous species, such as the earthworm *Dendrobaena rubida*, greatly increased in number. Immigration of fauna from the subsoil was only seen to occur sporadically.

In the garden and household refuse compost, the compost-worm *Eisenia foetida* multiplied rapidly. The heap teemed with adults but the young ones were not capable of going very far. The remaining fauna consisted of flies and certain species of beetles, which were attracted by the gases released by decomposition.

In the laboratory, *Eisenia foetida* developed within 3 months from egg to adult. The imagines live for at least 18 months. The food substratum seemed to be fairly rapidly exhausted by the worms.

### Future research

New views and techniques are constantly changing the methods of treating our agricultural, horticultural and silvicultural areas. Experiments in many parts of the world have revealed that interference (by which is meant something more than the mere use of biocides) has a profound effect on soil organisms. Ploughing, harrowing, crop rotation and other cultivation measures may cause certain organisms to get the upper hand and may inhibit the development of others. For instance, very intensive tillage of the topsoil can of course result in high mortality among earthworms. Deep ploughing will send surface fauna deep into the soil, where some species cannot survive.

The fact that the fertility of the soil is largely dependent on the living organisms in the soil is becoming ever more widely recognized. The nature of that dependence is known only in the case of a few species. As we gain an understanding of the link between soil fertility and soil communities we shall undoubtedly discover how to use the soil in such ways as will maintain the fauna community most conducive to fertility. As long as little is known about this community, about the interaction between its components and its relation to soil fertility, our cultivation methods and our endeavours to improve them are still imperfect. The object of Itbon's soil-biological research should be to supply bricks for the foundation.

There is another reason why we should endeavour to increase our knowledge of soil communities. Our crops are being increasingly threatened by pathogenous soil organisms which, by virtue of their interaction with other soil organisms, can both stimulate and check one another's growth through antibiotic activity, fungistasis, decomposition of fungi by bacteria and predation of fungi by mites. A more thorough knowledge of soil organisms might help us to devise a 'harmonious' method of controlling soil pathogens.

*Chapter 8*

# OTHER RESEARCH

## *Ascarid infestation of man*

Since there were indications that Roundworm *(Ascaris lumbricoides* L.) infestation was fairly widespread among the population of certain regions in the Netherlands, the Organization for Applied Scientific Research in the Netherlands (T.N.O.) requested Itbon to investigate. The research work was done by VOÛTE, who collaborated with J. A. TROELSTRA under the guidance of PROFESSOR DR. J. P. H. JONXIS of Groningen University.

Serious infestation was found to occur only in families who treated their kitchen gardens with human manure. But the mortality among Roundworm eggs in the kitchen gardens was such that the gardens could not have been sources of infestation (VOÛTE 1961, see Table).

*Table* – DECREASE OF ASCARIS EGG COUNTS IN 500 CCM OF SOIL AFTER SPRING DUNGING.

| | Samples of surface-layer | | Samples taken at about 10 cm depth |
|---|---|---|---|
| May: | 12–0–4–0–3–0–7–10–3 | May: | 0–0–0–0–5–0–4–7–0 |
| August: | 0–0–0–0–0–0–4– 0–0 | August: | 0–0–0–0–0–0–0–0–0 |

The source of infection proved to be located almost exclusively among families living in highly insanitary conditions (badly fouled privies). It was found that bigger cesspools which would overflow less frequently would help to control Roundworm infestation. (TROELSTRA a. VOÛTE, 1956; VOÛTE, 1961.)

Experiments carried out to discern the life-span of Ascarids found in the intestines of slaughtered pigs showed that there is a regulatory mechanism as a result of which the rate of growth of the Ascarid population slows down as the population density increases. Two phases can be distinguished: (1) the penetration of the larvae into the intestinal wall and the migration of the larvae through the liver and lungs causes the host to react in such a manner that the mortality among the migrating larvae steadily increases, and (2) the presence of Roundworms in the intestines retards the development of other worms. (VOÛTE, 1958b.)

It was hardly conceivable that there should be a regulatory mechanism outside the host, i.e. one inducing greater mortality among eggs as their number increased; indeed, there was no evidence of the existence of any such mechanism.

*Toxocara canis L.*

The literature on the subject shows that larvae of the worm *Toxocara canis* entering the human body sometimes cause serious pathological upsets, but little was known about the effects of slight infestation. BRUNT studied the subject.

He demonstrated that, as with *Ascaris lumbricoides*, the eggs' life span in the soil was brief. Areas heavily infested with eggs were free from them after a few months. The infestation of the soil was found to be very discontinuous. This was due to the fact that the eggs were deposited on the area in question together with the faeces and if they were not washed away with water of in some other way they would remain where the faeces were.

BRUNT did not find any eggs in any dwelling with infested puppies.

From this it can be inferred that there is little likelihood of human beings becoming infested.

Doctors were requested to supply information on any kennel keepers among their patients, since the latter come into frequent contact with *Toxocara*. No special diseases were found among them. The obvious conclusion is that a slight infection rarely results in serious illness.

Attempts to develop a specific reaction in human beings to the presence of *Toxocara* failed.

Since the investigations showed that there is not much risk of infestation with *Toxocara* eggs, the work was discontinued.

*Chapter 9*

# REVIEW AND PROSPECTS

It is amply clear from the foregoing chapters that the object of the research undertaken by the Institute is to discover what actually happens in the field. The fact that an important part of the work is carried out in the laboratory, on which, moreover, exacting demands are made, is irrelevant. For the sole purpose of this side of the work is to obtain a better understanding of observations made in the field.

The research work concerns individual plants and animals, populations, complexes of populations which together form a biotic community, and landscape elements such as heath, screens of trees, etc., all in relation to their environment. The ultimate object of studying these relations is to find out whether the subject concerned can survive and hold its own and, if so, how and to what extent. According to a current biological conception, it is the latter objective that places it in the category of ecological research [1]. Causal analysis of these relations is a welcome aid to increasing our understanding. Working with correlations can also be of assistance; it replaces causal analysis in many cases, or forms an introduction to it. Thus ecology is not a causal-analytical science, but causal-analytical methods are used in it wherever possible.

So Itbon, as an ecological institute, makes use of correlative as well as causal-analytical methods in its attemps to gain a better understanding of what goes on in our countryside, both natural and cultivated. The landscape is of course the ultimate environment in relation to which the subjects of research are seen.

For purposes of a causal-analytical investigation the landscape is of unmanageable size. We therefore have to confine ourselves to certain elements within the landscape, such as weather conditions in so far as they are modified by the nature of the landscape, root competition, predators or parasites. If the above relations concern an individual, we speak of aut-ecological

[1] It is teleological in the modern sense (see C. J. VAN DER KLAAUW, What is ecology? Proceedings. Royal Netherlands Academy of Sciences, Series C 57, 4, 1954: pp. 390–401).

research; if they concern a population or biotic community we speak of syn-ecology; if they concern individuals in relation to the population we call it population ecology; the relation of a landscape element to the landscape in general has so far not been named as a distinct section of ecology. It must be emphasized that in all these cases it is not the relationship as such that is the ultimate object of the research, it is to acquire a knowledge of the conditions that must be fulfilled if a particular organism is to be maintained.

In the course of our research work it became increasingly clear to us that in many cases the possibility of survival of individual creatures, populations or biotic communities is dependent on the structure of the landscape. I would define landscape ecology as the branch of science that deals with the relation between these objects and the landscape in the light of the question whether or not they will survive and develop.

We should try to understand landscape-ecological relations by correlative or causal-analytical methods. A single example may serve to illustrate this. When the population density of the Gypsy Moth *(Lymantria dispar)* and the Brown-tail Moth *(Ocneria chrysorrhoea)* is low, these insects can survive in relatively large numbers only in a few well-defined parts of the area. To find out why this happens, the caterpillars are studied in relation to their food supplies (aut-ecological research), and the effect of their density on their distribution is noted (population-ecological research), the incidence of parasites and predators is observed (syn-ecological research), and finally the whole gamut of interrelations is surveyed. Fundamentally, however, all these types of research are part of landscape ecology, because their object is to establish the chances of survival of the species in certain parts of the landscape.

The landscape is not a biological datum. It is the product of interaction between the mineral composition of the soil, water, air, soil organisms, land and water fauna and vegetation, not to mention the often dominating influence of man. Landscape ecology embraces all the interactions between micro-organisms, flora and fauna and the landscape. It is thus without doubt a biological science, but it could with equal justification be classed as a branch of geography. Landscape ecology forms common ground for these two sciences.

It is apparent from the following that most of Itbon's work falls within the scope of landscape ecology.

Soil-biological research deals with the decomposition of organic material in the soil and the development of soil structure that accompanies it. Consequently, this branch of research embraces the entire surface stratum, which is so determinative of the landscape as a whole.

In the work on insect pests the relation between the insect and its food-plant is gradually becoming paramount. The importance of a tree as food for an insect is seen to depend on the type of soil and the position of the tree in the landscape. Furthermore the incidence of disease, parasites and predators often depends very much on climatic and other conditions. The capricious manner in which many outbreaks occur and their evident association with the environment is discussed in the chapter on Forest Entomology and a number of examples are given.

The population dynamics we go in for embraces the regulation of species under various conditions ultimately determined by the landscape.

The landscape ecology aspect is particularly important in game research. Because of their great mobility, most of the species of game found in this country need to range over a wide area. For some game species there has to be plenty of open country where the animals can forage, as well as good cover. But even if these conditions are fulfilled, there is sometimes no game. It is not so much the presence or absence of a certain type of vegetation as the nature of the landscape which determines whether a certain species of game will survive. Busy main roads can render the best natural habitat unsuitable for some species of game. Any disturbance of countryside inhabited by game can make game-management difficult. And there is another point. Some kinds of grass are eaten by deer in certain circumstances but not in others. In the latter event the deer turn to other food, often very much to the detriment of the woods. The landscape-ecological approach also opens up some prospect of solving the problem of damage caused by game.

Research into the dunes involves the relationship between the dune landscape and man using it for recreational purposes. How the landscape can be protected in spite of more intensive use for recreation, and what effect this will have on the user, are among the problems arising here.

*

In this chapter we pointed out the duality of landscape ecology as a branch of both biology and geography. Consequently, the use that will ultimately be made of the results of our work will depend upon the use to which the the soil is put.

If maximum benefit is to be derived from our research, it will be necessary to adopt a policy of integration, i.e. there should be true co-operation when reaching decisions regarding the purposes for which land shall be used. This is revelant, not only when an area is designated for a new purpose, but also when we are dealing with a situation of long standing. The way in which one area is used can make it difficult for adjoining areas to continue to perform their existing functions. For instance, imagine the effect of using pesticides in an orchard bordering on an area which it is desired to preserve in its natural state.

Since it cannot be taken for granted that those actually using land and those who decide on the uses to which land shall be put will always be sufficiently aware of one another's problems, Itbon conceived the idea of preparing a book which would enable everyone to grasp the overall picture. The idea has been worked out by D. BURGER HZN. (1962). In our opinion the book can be regarded as being in a certain sense complementary to the work of our Institute.

*

Further development of landscape ecology seems to me to be essential for the future research work of our Institute, indeed not only for Itbon but for agricultural research in general. In my opinion Itbon can and should contribute to the development of this branch of science. Its usefulness in the whole field of agricultural research will partly depend on the way in which it does this. That does not mean that the Institute's development in the distant future will have to follow these lines. Ten years ago we thought that population dynamics would form the nucleus around which the entire investigation could be built up. This is certainly no longer so; on the contrary, even population dynamics seems to be veering towards landscape ecology in our research. If Itbon remains a vital establishment, which it certainly is at present, I anticipate that when its Golden Jubilee is celebrated, field research will still be in the centre of things but that the method of approach will have outgrown both population dynamics and landscape ecology. I shall not venture to make any predictions concerning the line along which Itbon will develop, because they would certainly not be borne out by events.

## *LIST OF RESEARCH WORKERS*

The list contains the names of research workers who have done research for Itbon and are referred to in the foregoing pages or in the list of publications.

Female research workers are marked '*'.

'M' in the next column means member of the staff, either established or unestablished. Many of the other members of the teams were undergraduates doing research for university degrees in biology or in agriculture, horticulture or forestry.

'T' means thesis based on the research undertaken.

The period and the nature of the research are given in the third and fourth columns, respectively.

| | | | |
|---|---|---|---|
| ALTENA, A. C. VAN | | 1951 | Forest insects *(Diprion pini)* |
| BAKKER, M. A.* | | 1961-1962 | Social insects (ants) |
| BALEN, J. H. VAN | | 1954-1955 | Game biology (reproduction of *Limosa)* |
| BESEMER, A. F. H. | T | (1938)-1941 | Forest insects *(Diprion pini)* |
| BLANKWAARDT, H. F. H. | M | 1950-now | Forest insects – Insecticides in soil – Population dynamics |
| BOER, M. H. DEN | M | 1965-now | Population genetics |
| BROEKHUIZEN, S. | | 1963-1964 | Social insects (wasps) |
| BRUÏNE, H. M. M. DE* | | 1964 | Population dynamics |
| BRUNT, G. | | 1960-1964 | *Toxocara canis* |
| BUNGENBERG DE JONG, J. * | | 1962 | Population dynamics |
| BURGER, H. C. | | 1950 | Forest insects *(Hylobius)* |
| BURGER HZN., D. | | 1959-1962 | Use of the soil |
| BIJL, J. W. | | 1964-1965 | Social insects (ants) |
| CROMBRUGGHE DE PICQUENDAELE, S. A. DE | | 1962-1963 | Game biology (reproduction of Red Deer) |
| DONKER, J. | | 1955-1957 | Forest insects *(Monoctonus)* |

| | | | |
|---|---|---|---|
| DOOM, D. | M | 1958-now | Forest insects |
| DOORN, Z. VAN | | 1948-1949 | Dune vegetation |
| DOUDE VAN TROOSTWIJK, W. J. | M | 1960-now | Game biology |
| DRIFT, J. VAN DER | M T | 1942-now | Soil fauna |
| ELTON, E. T. G. | M | 1945-now | Forest insects – Social insects |
| EYGENRAAM, J. A. | M | 1948-now | Game biology |
| FUCHS, P. | M | 1965-now | Insecticides in soil |
| FRANSEN, J. J. | M | (1938)-1943 | Forest insects |
| GLAS, P. | M | 1955-1957 | Game biology |
| GRUYS, P. | M | 1959-now | Population dynamics |
| GUNST, J. H. DE | M | 1959-now | Taxonomy |
| HAAFTEN, J. L. VAN | M T | 1958-now | Game biology |
| HEIN, G. | | 1949-1955 | Forest insects *(Diprion sertifer)* |
| HOLLEMAN, H. C. | M | 1950-now | Social insects |
| HORDIJK, C. V. * | | 1963-1965 | Forest insects – Social insects |
| JONGE, C. DE | M | 1963-1965 | Population genetics |
| JOOSTEN-VAN DEN BROEK HUMPHREY, F. * | | 1963-1964 | Population dynamics – Soil biology |
| KLEINHOUT, J. | M | 1952-1958 | Social insects (wasps) |
| KLOMP, H. | M[1] | 1949-1956<br>1962-now | Population dynamics |
| KRUIZINGA, D. | | 1959 | Social insects *(Atemeles)* |
| LINDE, R. J. VAN DER | M T | 1942-now | Landscape ecology |
| LUITJES, J. | M T | 1952-1963 | Forest insects |
| MIEDEMA, A. * | | 1961-1962 | Social insects (ants) |
| MINDERMAN, G. | M | 1948-now | Forest insects – Soil ecology |
| NAGEL-DE BOOIS, H. M. * | M | 1962-now | Soil mycology |
| NATHANS, S. | M | 1955-now | Soil fauna |
| NIEUWDORP, P. | | 1942 | Soil fauna |
| NOORDAM, D. | | 1942 | Soil fauna |
| PELKWIJK, A. J. TER * | | 1941 | Forest insects *(Coleophora)* |
| PELS RIJCKEN, P. H. | | 1961-1963 | Game biology (damage to Scots pine) |

[1] Extraordinary since 1962.

| | | | |
|---|---|---|---|
| PELSMA, C. * | | 1940-1941 | Forest insects (larch insects) |
| PIETERS, J. | M | 1956-now | Game biology |
| QUISPEL, A. | | 1940 | Social insects (ants) |
| RHEE, J. A. VAN | M T | 1954-now | Windbreaks – Soil fauna |
| ROOSEBOOM, M. * | M | 1942-1945 | Soil fauna |
| SCHOTVELD, A. | | 1963-1964 | Forest insects |
| SCHUILING, A. L. * | | 1940-1941 | Forest insects *(Stephanitis)* |
| SHAH, S. R. H. | T | 1959-1962 | Windbreaks |
| SLOOTEN, H. J. VAN DER | | 1952-1953 | Forest insects |
| SMIT, J. J. | M | 1956-now | Game biology |
| SNIJDERS, W. G. F. | | 1950-1958 | Windbreaks |
| STEEMERS, W. F. | | 1949-1950 | Forest insects *(Hylobius)* |
| STEENSMA, F. A. | | 1954-1957 | Game biology (repellents) |
| STORTENBEKER, C. W. | M | 1964-now | Game biology |
| TERPSTRA, P. | | 1943 | Forest insects |
| TICHELMAN, L. G. | | 1949-1950 | Forest insects *(Hylobius)* |
| TINBERGEN, L. | M | 1942-1949 | Population dynamics |
| VAART-DE VLIEGER, S. H. VAN DER * | | 1942 | Soil fauna |
| VAN DER LINDEN, M. J. H. A. | M | 1964-now | Soil ecology |
| VOOYS, C. G. N. DE | | 1960 | Social insects (ants) |
| VOÛTE, A. D. | M | 1940-now | Forest insects – Population dynamics – Other subjects |
| VOÛTE, A. M. | | 1961 | Population dynamics |
| WAL, A. F. VAN DER | M | 1955-1959 | Pheasants |
| WALENKAMP, J. F. G. M. * | | 1943 | Forest insects *(Retinia)* |
| WENT, J. C. * | M | 1946-now | Disease of the Dutch elm – (s. 1953) Soil bacteriology |
| WESTHOFF, V. | | 1941 | Social insects (ants) |
| WESTHOFF-DE JONCHEERE, J. N. * | | 1941 | Social insects (ants) |
| WEYLAND, W. A. | M | 1962-now | Game biology |
| WIND, R. | | 1950-1952 | Dune vegetation |
| WITKAMP, M. | M T | 1950-1960 | Soil mycology |

# III.

# PUBLIKATIES / PUBLICATIONS

INHOUD



CONTENTS



De met * gemerkte publikaties zijn nog verkrijgbaar.

Publications marked * are still available.

Het Itbon geeft twee series van publikaties uit: 'Mededeling Instituut voor toegepast biologisch onderzoek in de natuur' (in deze lijst kortheidshalve aangeduid met 'Mededeling Itbon') en 'Itbon-overdruk nr. E . . .'.

Gestaakt zijn: de serie 'Mededelingen Comité ter bestudering en bestrijding van insektenplagen in bossen' en de serie 'Mededelingen Comité ter bestudering en bestrijding van ziekten in iepen en andere boomsoorten'.

De in deze lijst genoemde publikaties zijn in de onderscheidene groepen chronologisch op auteur gerangschikt.

Voor de afkortingen is gevolgd de World List of Scientific Periodicals 1900—1960, Londen 1963—1965.

Aanvullingen op deze literatuurlijst worden in onze jaarverslagen opgenomen.

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Itbon issues a series of publications: 'Mededeling Instituut voor Toegepast Biologisch Onderzoek in de Natuur' (abbreviated 'Mededeling Itbon' in this list) and a series of reprints: 'Itbon-overdruk nr. E . . .'.

Two series of publications have been discontinued, viz. a series dealing with forest insects ('Mededeling Comité ter bestudering en bestrijding van insektenplagen in bossen') and a series dealing with the elm disease ('Mededeling Comité ter bestudering en bestrijding van ziekten in iepen en andere boomsoorten').

Each author's publications are listed in the various groups in chronological order.

The abbreviations are those used in the World List of Scientific Periodicals 1900-1960, London 1963–1965.

Additions to this list of publications will be found in our annual reports.

| | | |
|---|---|---|
| * ELTON, E. T. G. | 1956a | Aantasting van moll-platen door de kleine wasmot *Achroia grisella* Fabr. (Lep. Pyralidae). With summery. – Ent. Ber. Amst. *16:* 12-14. Itbon-overdruk nr. E 64. |
| * GUNST, J. H. DE | 1963 | Handleiding systematische entomologie voor de cursus van het Instituut voor Toegepast Biologisch Onderzoek in de Natuur. – 111 p. |
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## Bosinsekten — Forest insects

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