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A Community of simulium species in the Vaal River near Warrenton

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A COMMUNITY OF *SIMULIUM* SPECIES IN THE VAAL RIVER NEAR WARRENTON

VOLUME I

Text with 28 Tables, 36 Figures and 17 Plates

Ferdinand Cornelis de Moor

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University of the Witwatersrand, Johannesburg, in partial
fulfilment of the requirements for the degree of Doctor of Philosophy.

Johannesburg, 1982

ABSTRACT

This investigation was aimed at identifying factors which influenced the abundance of the aquatic stages of Simuliidae in the Vaal River near Warrenton. The life cycle, biology and ecology of *Simulium chutteri* Lewis the dominant species was studied in detail.

Methods were devised to obtain estimates of simuliid population levels. The densities of Simuliidae and other benthic fauna from the stones-in-current in a rapid were monitored over an extended period of time. Aquatic drift proved to be a good indicator of recruitment rates of various benthic invertebrates.

Simulium chutteri goes through seven larval instars to pupation. Temperature influenced seasonal variation in duration of the life cycle and size of individual developmental stages. Although it appeared that there were sometimes more than seven larval instars during winter, statistical analysis revealed that this was not so. The development of large larvae and pupae in winter would lead to more fecund adults appearing in spring. This coincided with low aquatic and terrestrial predation and could lead to rapid growth of blackfly populations in spring.

Habitat preferences and seasonal abundance of the four most commonly encountered simuliids; *S. chutteri*, *S. adersi* Pomeroy, *S. damnosum* sensu lato Theobald and *S. mamahoni* de Meillon were examined. Ovipositing in the open water and the use of drift as a dispersal and colonization activity distinguished *S. chutteri* from the other simuliid species.

Interspecific competition between the various simuliid species was not intense and a coexistence of various species was often seen. With a continuously fluctuating species-niche the habitat favoured different species temporally and spatially leading to seasonal peaks of abundance of the various *Simulium* species.

Knowledge of the ecology and biology of *S. chutteri* was used to devise an integrated programme, utilizing natural seasonal phenomena and artificial river flow manipulations, to control the population size of this pest species and prevent serious outbreaks, which would pose a threat to livestock farmers, from occurring.

DECLARATION

This is to certify that the contents of this thesis are my own unaided work, excepting for assistance with, and analysis of statistical data presented in the appendices which is further acknowledged in the text. Assistance with identification of various faunal and floral groups by various specialists and technical assistance in the analysis of data by my wife, Irene, are separately acknowledged. The material that formed the basis of the work was collected by me from the lotic water environs near Warrenton. I furthermore declare that neither the whole nor part of this data has been, is being, or will be submitted for a degree at any other University.



Ferdinand Cornelis de Moor

November 1982

DEDICATION

To my father and mother who instigated my interest in nature, and my wife Irene whose encouragement and help assisted in the completion of this work.

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To my father and mother who instigated my interest in nature, and my wife Irene whose encouragement and help assisted in the completion of this work.

PREFACE

To facilitate the reading of this thesis the description of some of the techniques developed as well as methods and details of data detracting from the general flow and theme of the text were placed in separate appendices. In addition actual counts of fauna from artificial and stones-in-current substrates, from which average values of data in tables and figures in the thesis' text and appendices were calculated, have been stored in files obtainable from the National Institute for Water Research (NIWR) at the CSIR in Pretoria, the Zoology Department of the University of the Witwatersrand in Johannesburg or from me.

A semi-applied approach of the research was directed towards obtaining early warnings of the population size of adult blackfly (Simuliidae). In order to prevent outbreaks of pestilential numbers of these cattle biting midges from occurring possible methods to manipulate the population size of the aquatic pre-adult stages of the fly were examined.

To control the population size of blackflies it was endeavoured to establish a method which would be ecologically the least disruptive and for that reason the research was also directed at devising a control method which did not make use of pesticides. To do this it was necessary to determine the habitat preference and ecology of the various simuliid species commonly encountered. To determine if and why seasonal population increases in particular blackfly species occurred, the type and duration of the aquatic life cycle of the various species as well as their population density fluctuations had to be studied. Various other biotic and physical variables like predators, parasites, flow rates and temperature were also recorded throughout the study to assess if they could have played a role in influencing simuliid population levels.

As the title of this thesis implies, the study was involved with *Simulium* species on the Vaal River and how these species interacted in a community. The approach taken was to study the biota at various localities along the Vaal River and also in a small stream entering the Vaal River. Studies were limited to the aquatic environment as this was the region where individuals would predictably remain for a major part of

their life cycle, was easily accessible, and was also less affected by minor environmental fluctuations than the terrestrial aerial environment of the adult stages.

Detailed studies on fluctuations of simuliid populations, other biota, and physical parameters were carried out at a selected site in the Vaal River. From this detailed study it was possible to examine any factors which may have affected population fluctuations. Natural predators, parasites, and the manipulation of environmental factors (the flow regime of the river) could then be used as an integrated management programme to control the population size of Simuliidae.

Some of the data presented in Chapter 6 was separately published (*Can. J. Zool.* 1982, 60, 1374-1382) before the submission of this thesis.

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Without the assistance and guidance of many people, the writing of this thesis would not have been possible. I wish to thank the following persons and institutions for inspiring and assisting me in the completion of this work:

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The CSIR for providing funds through its Co-operative Scientific Programme (CSP) to finance the research, and Mr R W (Bob) Crowe who first told me about the research opportunity.

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Mr A S Dippenaar (Arachnida)
Dr E C G Pinhey (Odonata)
Dr R Phelps (Mermithidae)
Dr R W Crosskey (Simuliidae)
Dr D J Lewis (Simuliidae)

Lastly I would like to thank Mrs J du Plessis of the NIWR for the typing and final layout of the manuscript.

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1. GENERAL INTRODUCTION

Adult blackflies (Simuliidae) are small, stout-bodied midges which show a wide variety of feeding adaptations, from not feeding at all, to feeding on plant nectars, or on the blood of birds and mammals including man (Crosskey, 1973).

The subimaginal stages of blackflies are among the most adapted of all animals to life in fast flowing water, and water-current velocity is in most cases a limiting factor in the distribution of their larvae and pupae. The larvae of Simuliidae have large silk-producing glands which are functional from the emergence of the first instar (Tarshis and Neil, 1970). A tangled mat of silk is usually spun onto the substrate and the larvae affix themselves to this by means of hooks on highly modified prolegs. An anterior ventral proleg projects forewards under the head and a posterior proleg, flush with the larval body surface so as to be scarcely recognisable as a proleg, forms the rear end of the body and is situated below the upwardly turned anus. A complex arrangement of muscles disengages and engages the circlet of hooks, present on both prolegs, and enables larvae to grasp the silken mats which they spin on the substrate. Locomotion is carried out by engaging and disengaging alternatively the anterior and posterior prolegs and by looping foreward on newly spun patches of silk. In cases of emergency larvae are able to release their hold from the substrate entirely and can then float downstream leaving behind a trailing stream of silk attached to the previously occupied substrate. When larvae encounter another suitable substrate they settle once more.

Pupae too are highly modified and are usually housed in a 'shoe' or 'pocket shaped' cocoon with the closed pointed posterior end facing upstream. The pupae are safely embedded inside the cocoon by means of dorsal, ventral and sometimes terminal hooks which catch in the silken strands of the cocoon. In the species found in faster flowing waters the 'shoe shaped' cocoon has a lip for further holding the pupa firmly inside its silken case.

Respiration in larvae occurs cutaneously and possibly in the rectal gills (Imms, 1965). These gills were however considered to have an

osmoregulatory function by Crosskey (1973). The pupae respire through the branching and variously shaped thoracic spiracular gills (Hinton, 1964). Feeding in the larval stage is mostly carried out by the filtering of fine particulate organic matter from the flowing water by means of modified pre-mandibular appendages forming cephalic fans, although occasional browsing also takes place (Craig, 1977).

As is evident from the detailed description (Ch. 2), the Vaal River downstream of the Vaalhartz Diversion Weir has a large number of fast-flowing, stony-bottomed stretches of water which are suitable as habitats for the aquatic stages of Simuliidae.

It was shown by Muller (1953), Chutter (1963) and Quelennec *et al.* (1968) that the damming up of rivers could lead to significant increases in the numbers of filter-feeding animals, and in particular Simuliidae, in rapids below impoundments. The Vaal River is dammed by the Vaalhartz Diversion Weir and immediately downstream in the Warrenton area Simuliidae, and in particular *Simulium chutteri* Lewis, were found to be the dominant faunal group (Chutter, 1968).

As adult *S. chutteri* females are known to feed on bovine blood (Howell and Holmes, 1969), one of the reasons for the abundance of this species near Warrenton would be the extensive cattle farming in the area. The combined effect of high nutrient levels in the man-made lakes upstream of the Vaalhartz Diversion Weir, leading to increased planktonic food and the fast flowing nature of the river, made this stretch of water ideally suitable for colonization by the aquatic stages of Simuliidae.

Periodic outbreaks of plague proportional densities of *S. chutteri* have been recorded in the Vaalhartz area (Howell and Holmes, 1969). Adult blood-sucking females of Simuliidae are known to be transmitters of various pathogenic diseases in livestock and man (Crosskey, 1973) and when present in large numbers adversely affect condition in livestock through excessive blood feeding (Steenkamp, 1972). Application of insecticides and water flow manipulation to control the population size of Simuliidae were carried out with success (Howell and Holmes, 1969; Howell *et al.*, 1981), but it remained necessary to determine how and when the most effective methods of control could be applied.

Disney (1972a) states that 'as we move away from the effective, but ecologically damaging, larvicides such as DDT to more sophisticated and more selective methods of control, we will almost certainly require more precise estimates of population levels of pre-imaginal black flies'. Bearing this statement in mind it was necessary to study the life cycle of *S. chutteri* and the interaction of this species with other biotic and physical parameters in the environment. It was also necessary to determine which factors influenced the life cycle and population size of *S. chutteri*, and the various other simuliid species encountered in the waters around Warrenton to enable the formulation of a programme to manage the population size of *S. chutteri* and determine why that species and not other *Simulium* spp. attained such large populations.

Factors pertaining to the adult life cycle like feeding, mating, ovipositing activity, migration, longevity and size of the adult population all play an important role in colonization, dispersal and seasonal abundance of Simuliidae. A thorough investigation to determine the role the adult stage played would however have required an intensive time-consuming programme which would have detracted from the efficiency of a survey on the developmental stages of Simuliidae found in the aquatic environs around Warrenton. Population size estimates are far easier to measure in the aquatic stages as larvae and pupae are not as strongly influenced by changes in the weather (wind and rain) and are not as complex in their behavioural pattern as adults (swarming, migration, resting and feeding). It was thus decided to limit studies described in this thesis to the aquatic stages of Simuliidae.

Taxonomically the Simuliidae are a complex family of nematoceran Diptera which show diverse speciation with 163 nomenclaturally described African species being recorded by Crosskey in 1969. Cytotaxonomic studies carried out by various workers (McRae, 1968, 1969; Dunbar, 1966, 1968; Dunbar and Vajime, 1972; Garms and Vajime, 1975; WHO report, Nov. 1976) indicate that there are probably far more valid simuliid species in Africa than the above number would suggest.

For identification of the various taxa encountered in this study, material was identified by various specialists (see acknowledgements) or else various identification guides were used (see taxonomic references).

2. THE GEOGRAPHY OF THE VAAL RIVER IN THE WARRENTON AREA

The town of Warrenton had a population of 9 479 in 1970 (Anon, 1973), and supports the local community of farmers and railway workers. There is a cheese factory at Fourteen Streams, which lies just North of the Johannesburg road about 1 km beyond the railway crossing (see Ch. 3, Fig. 1) but otherwise local industries are of minor importance. Most of the information pertaining to the geology and climate of the Warrenton area was obtained from Kleynhans (1980).

Geologically the area around the Warrenton district is made up of andesitic lavas of the Ventersdorp supergroup which form a plateau running from the North-East to the South-West. Along this plateau the Vaal River cuts a course nearly parallel to the Kaap Valley which lies to the West of the river. The Hartz River flows in this valley and joins the Vaal River near Delportshoop.

The bedrock of the Vaal River is made up of all possible gradations of lavas between amygdaloid, non-amygdaloid to porphyritic and non-porphyritic rocks. Consequently boulders and stones in the river are either smooth (*ca.* 90 per cent) or of a vesicular amygdaloid type (*ca.* 10 per cent) with many small cavities which provide excellent refuge for many of the aquatic invertebrates, particularly larval Hydropsychidae.

The Vaal River flowing parallel to and at a higher altitude than the Hartz River Valley made this region ideally suited for irrigation purposes. Vaal River water is diverted at the Vaalhartz Diversion Weir into an extensive system of approximately 110 km of canals. These extend northwards and eastwards to form the largest irrigation scheme in the Southern Hemisphere.

Over a stretch of 164 km between the Vaalhartz Diversion Weir and Delportshoop, at the junction of the Vaal and Hartz Rivers, the Vaal River drops 174 m in altitude. Between the Vaalhartz Diversion Weir and Windsorton, a 45 km stretch of river, the Vaal River has an even more marked 74 m drop in altitude. A profile diagram of the lower regions of the Vaal River was given by Chutter (1968). The rapid drop in altitude of the river in conjunction with the hard basaltic origin of the river-

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