"BLACKFLIES" LORDS OF THE RAPIDS

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Blackfly, Buffalo Gnats, Black Gnats, River Midges or Reed Smuts are some of the common names that have been applied to a group of two-winged river flies that belong to the family scientifically known as Simuliidae. In southern Africa, taking into account all the rivers south of the watersheds of the Zambezi and Kunene Rivers, there are approximately 60 species of blackfly. They are divided into two genera: *Prosimulium* with nine recorded species with a distribution restricted to small streams in the mountainous regions of the South Western Cape, the Brandberg in South West Africa and granite domes near Harare in Zimbabwe; and *Simulium* with many widespread species adapted to a variety of flowing water conditions (Crosskey 1987). Adult blackflies are frequently confused with other small flies that are found near flowing water habitats but which do not have aquatic larval and pupal stages found in swift flowing waters like the Simuliidae. A brief description of the aquatic and aerial adult stages will perhaps help to clarify this confusion.

Both larvae and pupae of blackflies show extreme specialisation for an existence in swift flowing waters (Figures 1 & 2). Because of their life in running water, larvae lead an almost entirely sedentary life and have poor locomotory powers relying on the moving water column to provide food and keep dissolved oxygen levels at the required high levels. The larvae go through seven discrete growth intervals or instars before pupating. They are elongated pear-shaped with the hind part wider than the head end. The head is a rounded helmet shape with darkened eye spots on either side, the cuticular surface is frequently pigmented forming darkened crosses or circular ornamentations but in certain species remains pale and unpigmented. At the front end, the head has a pair of prominent retractable fan-shaped organs made up of a large number of rod-like rays with minute hairs, which are used to extract fine particulate food matter from the passing water. Immediately below the head on the underside of the body there is a single finger-like proleg which is adorned with a terminal circlet of little hooks. The hindpart of the larva has a large sucker-like disc (actually also a proleg) which has several circular rows of hooks. In size larvae vary in total length from less than ½ mm for the smallest first instar to 13 mm for the largest final instar.

In their normal activity larvae of different species can usually be found on stones, submerged vegetation or any form of substrate found in swift flowing water. They are attached with their disc prolegs hooked into a small patch of silk which they have spun onto the substrate. Larvae remain in a semi-upright position when they are feeding, retracting into a more horizontal position closer to the substrate surface when resting. In the feeding position the head fans are extended and held with their concave surfaces facing the water current. Periodically they retract the fans and scrape off food particles which get caught up in a fine layer of mucous which is excreted onto the rays of the fans. Larvae of blackflies have been recorded as filtering out particles from 350 um down to 0.1 um (one ten thousandth of a millimetre) in diameter (Wallace and Merritt 1980). So in effect they are extremely good biological filters even able to remove very small bacteria from flowing water. When a larva wants to move into a more suitable flow of current, this can be achieved by spinning a small patch of silk onto the substrate surface immediately in front of it. By hooking the finger-like proleg into this new patch of silk and releasing hold of its former attachment with the sucker-like proleg and then drawing it to grip the new patch of silk, a very slow tedious form of looping locomotion can be achieved. Evasive escape locomotion can be achieved by releasing hold of the substrate but leaving an anchor line of silk attached. The water current then wafts the larva away from the immediate danger but keeps it within reach of its favoured swift-flowing water habitat.

The final instar larva, which is in fact a functional pupa within a larval skin, spins a silken cocoon before pupating. This can vary in form, depending on the species, from an open ended "slipper-shape" to a case with a closed protective ridge or "shoe-shape". Generally the species with the slipper-shaped cocoons are found in slower flowing waters than those with shoe-shaped cocoons. The pupa, which is immobile, has a number of little hooks on its body to ensure that it remains firmly imbedded inside its silken case and is not washed out by the swift flowing waters. At the head end of the pupa are a pair of simple or branched breathing

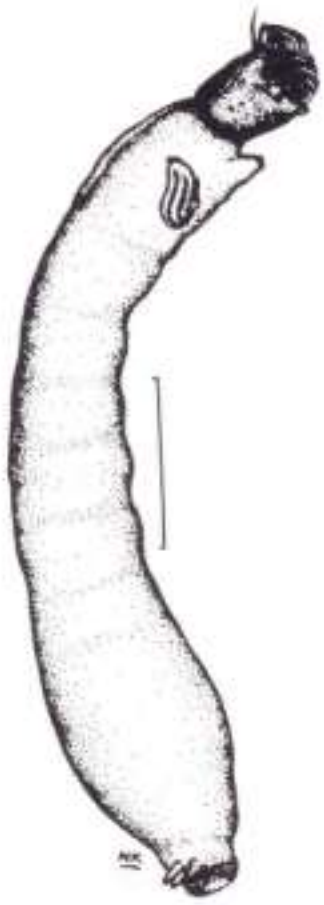

FIGURE 1. Larva of *Simulium chutteri*, showing head fans partially extended. Scale = 1 mm.

FIGURE 2. Top view of Pupa of *Simulium chutteri* in "shoe-shaped" cocoon. Scale = 1 mm.

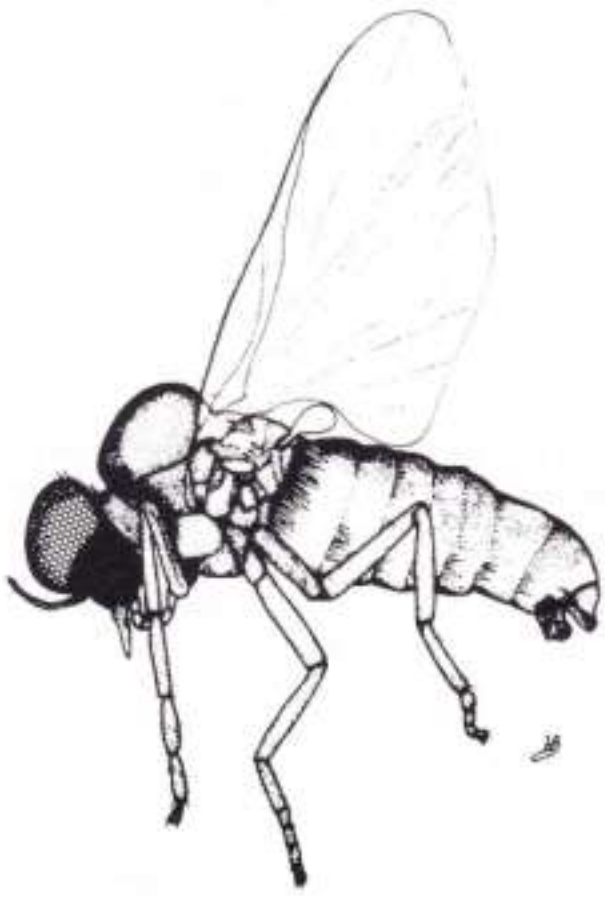

FIGURE 3. Adult male of *Simulium chutteri*, note two sizes of eye facets. Scale = 1 mm.

FIGURE 4. Sharp toothed catfish formation feeding on emerging blackfly below rapids in the Vaal River. (Photo F. C. de Moor).

filaments, also known as plastron gills. They are remarkable organs in that they extract dissolved oxygen directly from the water and will not wet, even under 10 m of water pressure (Hinton 1964). The shape of these respiratory gills is also species specific and provides one of the quickest and easiest methods of identifying blackflies (Freeman and de Meillon 1953, Crosskey 1969).

The adult stage of a blackfly is best recognised by its hump-backed shape (Figure 3) from which it derives the American name of Buffalo Gnat. They vary in size from 3 to 6 mm, about the size of a matchhead in layman's terminology. Size varies between species and also within a species between different seasons, larger sizes being attained during the cooler months of the year. Males and females are almost always (a few rare species excluded) sexually dimorphic. The males have eyes that meet in the centre of the head with large facets (ommatidia) on the top and smaller facets on the bottom, whereas females have eyes that are well separated in the centre and have uniformly sized ommatidia. The enlarged facets provide the males with more acute vision to enable better resolution of moving objects.

Male blackflies of many species form mating swarms either directly above rapids or else at some prominent feature near to the water's edge or even around a host animal. These swarms, made up almost entirely of males and comprising from a few to many thousands of individuals, are spectacular phenomena to observe. Under calm to windstill conditions the males orientate themselves around a marker and hover in such a fashion as to form an almost stationary column of flies. If a female enters the field of vision of males in the swarm she is immediately followed and clasped and mated by a male. In fact any small moving object thrown into the swarm will be eagerly followed by ardent males.

After mating the female fly either develops eggs directly from fat-body reserves accumulated during her larval life or else seeks out a suitable host to obtain a blood-meal and thereby proteins for egg development. After a period of egg maturation she returns to the water to oviposit her eggs. Oviposition habits vary between different species and can entail the simple scattering of eggs loosely on to the water surface, laying of eggs on reeds or other submerged plant matter or laying of eggs on partially emerging stones in shallow riffles. In the last mentioned case females actually alight on stones sticking out of the water and crawl up to 20 cm under the water surface where they then lay a patch of white eggs.

Blackfly are probably best known because many species are recognised as important blooksucking pests of man and his livestock. In West Africa species belonging to the *Simulium damnosum* complex are carriers of the filarial parasite *Onchocerca volvulus* which causes a disease known as river blindness in man. Unlike a mosquito which punctures a small hole into the skin and then pumps out the blood meal it needs, a blackfly chews a gaping wound into the skin and laps up or imbibes the blood that is exuded. Secondary infections in wounds are therefore frequently the most serious aspects of blackfly attacks. Many blackfly species do not feed in the adult stage whereas others are specialised for feeding on birds. The latter can usually be recognised by the shape of the tarsal claws (found terminally on each leg) which have an extra tooth for hooking onto the feathers of birds.

Simulium chutteri, a species which lives in the swiftest of flowing water currents in rapids, can at certain times of the year, be found in densities of up to 400 000 individuals or 600 g of blackfly per square metre of river bottom (de Moor 1982). In terms of number of individuals collected from stones in rapids, blackfly can form 95% or more of the total animals and hence can truly be considered as "lords of the rapids". Because of their abundance in and almost complete dominance of the swift-flowing water habitat, blackfly form an important component of the aquatic food chain. They are important primary consumers of planktonic plant matter and detritus held in suspension by the flowing water. In turn they are preyed on in their aquatic stages by secondary consumers such as fish, crabs, leeches, and other aquatic insects; in the adult stage by fish, birds, spiders, dragonflies and other predatory flies.

The duration of the aquatic development stages of Simuliidae are determined mostly by water temperature. There are basically two temperature barriers, the developmental and the maturation thresholds, which have to be attained and maintained for a sufficiently long time to allow the blackfly larvae to complete their life cycle (Ward and Stanford 1982). Below the developmental threshold temperature a larva ceases to grow and enters a state of torpor. Above this temperature a larva feeds and carries on growing, but if the maturation threshold

temperature is not reached then it will not pupate or metamorphose into the adult stage. Certain species are adapted to an existence in cool water whereas others cope more successfully with a warmer water temperature. The larger species are usually found in the cooler mountain streams but even within a single species a larger size is usually attained as the average temperature of the water decreases.

In the cooler regions of the northern hemisphere, distinct seasonal breeding is pronounced and a succession of emergences of different simuliid species occurs from spring through to autumn. In southern Africa, with a much warmer climate, breeding occurs all through the year and adults of a number of species can be found at almost any time of the year. There are, however, distinct population increases at certain times of the year, markedly so during the spring with increasing water temperatures and higher levels of primary (plant matter) production. Vertebrate predators such as fish and birds adapt their behaviour at such times to feed almost exclusively on blackfly. I was lucky to observe formation feeding and pack hunting, in *Clarias gariepinus*, the sharp toothed catfish or barbel, along the Vaal River near Warrenton on several occasions. Formation feeding, described by Bruton (1979), takes place when a number of barbel form a tightly-knit semi-circular group. They swim towards the shore or origin of the food source with their mouths open and their barbels or whiskers extended along the water surface, thus guiding material drifting on or just under the surface of the water into their mouths. This type of feeding concentrates the food source and maximises food gathering energy. Fish behind the leaders of the pack scoop up any food items not gathered by the leaders.

At certain times of their life cycle the behaviour pattern of larvae, pupae and adult blackflies makes them particularly susceptible to predation by fish, and it is this information which would be considered of greatest value to the angler. Many aquatic insects form an important component of the drift, which can be described as the downstream transport of organisms by running water. The importance of drift in supplying food for secondary consumers in running waters can be gauged by the fact that up to 35 times as many blackfly passed over one square metre of stream-bottom over a twenty-four hour period than were captured from that area (Pearson and Franklin 1968). It was also shown that there were more and bigger fish in areas of a stream where there was a high influx of drift than in other regions.

Waters (1972) identified three types of drift commonly found in aquatic insects which normally live on substrates on the stream bottom. The first, **constant drift,** was applied to the situation where low numbers of animals randomly entered the drift at all times of the day. This could be caused by minor disturbances caused by individual interactions of species or accidental loss of position on the substrate. The second type of drift identified was when unusual disturbances such as floods or a sudden decrease in the flow volume caused a massive increase of animals in the drift and was called **catastrophic drift.** Both over different seasons and during a twenty-four hour cycle distinct patterns of drifting activity were identified in certain species and this type of activity was called **behavioural drift.**

Constant and catastrophic drift can be found in all aquatic invertebrate species and can occur at any time of the year. Behavioural drift is, however, found only in certain groups of insects and is more pronounced at certain times of the year and during certain times of the day. It serves a specific purpose in the life cycle of a species and is, with good biological knowledge, fairly predictable. It can aid to disperse individuals into new habitats and serve as a colonising activity or it could be an important migratory phase of the life cycle serving to transport individuals that have attained certain development status into new microhabitat regions.

Elliott (1967) found that most of the behavioural drift occurred during the period when the most rapid development took place in a species' life cycle and that younger instars of blackfly larvae were more active drifters. Light intensity too influenced drift activity and significant increases of animals in the drift were recorded around dusk and dawn. Waters (1972) described the type of drift with a large peak at dusk followed by a smaller one at dawn as the bigeminus pattern. The alternans pattern showed a small peak of drift at dusk followed by a major peak at dawn.

Firstly, it is important to know at what times of the year the most active period of larval drifting occurs or when peak population densities of a particular species occur. Secondly, it is

important to know whether the dominant species of blackfly in rapids or riffles above a large pool show either a bigeminus or alternans drift pattern so that angling activity can be concentrated in such pools during the period of peak larval drifting activity. My personal experiences indicate that most of the simuliid species studied in South Africa so far show a bigeminus drift pattern and peak drifting activity usually occurs in the spring to early summer period when water temperatures are gradually increasing. With warmer water temperatures pupation and adult emergence rates increase and mass emergences of adults are frequently observed in spring. This period is a very good time for angling and a description of the emergence of a blackfly will indicate how this could be mimicked by the fly fisherman.

On completion of metamorphosis the adult blackfly, now encased in the pupal skin, releases air which accumulates between the body and the pupal skin. At emergence the adult fly splits the pupal skin lengthwise between the head and thorax and emerges head first enclosed in a bubble of air. Underwater the black body of the fly encased in a silvery bubble of air rises slowly to the surface. At the surface the bubble bursts and the fly, which is completely dry, takes to the wing. During this short period of the life cycle blackfly are extremely visible and highly vulnerable to predators making use of underwater sight. During the spring when mass emergences occur, individual flies are also larger due to development of larvae in the cooler waters during the latter part of the winter. These large adults usually have abundant supplies of fat-body reserves and provide an excellent source of protein-rich food as is well borne out by the frantic feeding activities shown by swallows, swifts, martins, pied wagtails and barbel at this time of the year.

South African species of blackfly fall into several categories. Species such as *Simulium chutteri, S. bovis, S. hargreavesi* and some of the *S. damnosum* complex species can be found in the swift turbulent waters of medium to large rivers. *Simulium gariepense* is adapted to the slower flowing regions of large, turbulent rivers such as the Orange. *Simulium adersi* is a widespread adaptable species common in small- to medium-sized rivers and favouring less turbulent, slower flowing water than the above species but is frequently found coexisting with them. It has even been recorded from brackish waters on a few occasions. *Simulium nigritarse* which is also very widespread and is a coloniser of newly formed streams can tolerate a wide variety of polluted water conditions. It is found in a wide spectrum of flowing water conditions from the smallest of trickles to large rivers but favours slow to moderate flows of water. There are several species which favour cool clear mountain stream conditions and these are considered as the torrenticolous species which are found in the swiftest of flows even clinging to rock surfaces in waterfalls. They include some of our biggest species with larvae growing up to 13 mm in length. Two species in this group *S. debegene* and *S. dentulosum* are probably of interest to fly-fishermen, just as the larvae, the adults are also large with a wing span occasionally attaining 20 mm.

To summarise this information and put it into the context which would make it useful for the angling fraternity we need to look closely at the life cycle stages that are most prone to fish predation. The time of the day and seasons of the year when fish are most likely to feed on blackfly (i.e. when they are most abundant) should also be identified. Unmistakably the larvae and adults are identified as the stages most likely to be fed on by fish. The pupal stage should not, however, be excluded as a major food source because I once collected a barbel and on examining its gut contents was amazed to find it jam-packed with *Simulium* pupae. Larvae would be in the drift at all times of the year, but a distinct seasonal increase could be expected in spring or when water levels are slowly dropping or rising. During such water level fluctuations one would expect fish to make opportunistic use of the increased supply of drifting food. Anglers might well try to model blackfly larvae with attached silk threads moving downstream with the current. The adult stage is vulnerable to fish predation during several periods of its life. Firstly, immediately after it has emerged from the pupal shuck and floats to the surface; secondly when male mating swarms fly very close to the water surface with occasional mating couples falling into the water and lastly when the female returns to the water to oviposit. The emergence period of the adults is undoubtedly the most vulnerable stage in the life of a blackfly. It is leaving its running water habitat for which it is highly specialised and during the transition to the terrestrial aerial environment, to which the adult is also very well adapted, it goes through an unfavourable environment in the drift in a highly conspicuous fashion. The mimicking of emerging blackfly adults encased in a

silver bubble of water should make a challenging task to the angler and to my opinion an irresistible food item for the fish.

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