

ACTIVITIES AND ECOLOGICAL ROLE OF ADULT AQUATIC INSECTS IN THE RIPARIAN ZONE OF STREAMS¹

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Abstract: Most adult aquatic insects that emerge from streams live briefly in the nearby riparian zone. Adult activities, such as mating, dispersal, and feeding, influence their distribution in the terrestrial habitat. A study at Big Sulphur Creek, California, has shown that both numbers and biomass of adult aquatic insects are greatest in the near-stream vegetation; however, adults can be relatively common 150 meters or more from the stream. Because adult aquatic insects are abundant, they represent a primary food resource for many riparian insectivores. The role of adult aquatic insects in the riparian zone must be better understood for riparian management plans to be complete.

The adult stages of most stream insects inhabit the riparian zone (e.g., Anderson and Wallace 1984; Erman 1984). Although adults are generally short-lived (from one day to a week), they often exhibit physical characteristics and life history traits that facilitate their survival in the terrestrial environment and their reproductive success (e.g., Butler 1984; Jackson 1988). Such adaptations suggest that the brief interaction between adult aquatic insects and the riparian zone has been, and presumably continues to be, important to their survival. At the same time, aquatic insects can influence the distribution and abundance of riparian insectivores because the adults of aquatic insects often represent an important food resource (Jackson and Fisher 1986). The purpose of this paper is to summarize some activities and roles of adult aquatic insects in riparian zones in California and other regions.

Activities of Adult Aquatic Insects

Adult aquatic insects engage in several activities, the most common of which are reproduction, dispersal, and feeding. Reproduction [i.e., mate location, followed by oviposition in the stream or on overhanging vegetation by females, see Anderson and Wallace (1984) for descriptions of the latter] is essential for the initiation of the next generation in the aquatic environment.

Reproductive activities are often well defined with respect to time of the day and location in the riparian

zone. Some species form mating swarms [e.g., mayflies (Ephemeroptera), caddisflies (Trichoptera), and chironomid midges (Diptera)] at specific times of the day, distances from the stream, and heights above the ground (e.g., Edmunds and others 1976; LeSage and Harrison 1980).

Recent studies in the Coast Range of northern California demonstrated that males of some species of caddisflies locate conspecific females by following sex pheromones (i.e., chemicals that mediate reproductive activities between males and females) that are released by females (Wood and Resh 1984; Resh and Wood 1985). Similar to swarming, pheromone-induced mating occurs at a specific time of the day. For example, the pheromone-induced mating period for *Gumaga nigricula* (McL.) (Trichoptera: Sericostomatidae) is in the morning and lasts only 3 to 6 h (Jackson and Resh, unpublished data).

Dispersal is also a key activity for most adult aquatic insects. The short-lived adult stage in many species (e.g., most mayflies, stoneflies, caddisflies) would appear to limit the distance that they can potentially disperse, either passively or actively. However, long distance (greater than 1 kilometer) movements both within stream corridors (e.g., Coutant 1982) and across land (e.g., Svensson 1974; Edmunds and others 1976) have been recorded for some species in these groups. Not surprising, long distance movements have been commonly observed in species that have relatively long-lived adults [e.g., some blackflies, mosquitoes, dragonflies (Johnson 1969)].

Long-lived adults often feed (e.g., they are predators or require a blood meal for egg development) and prey or host availability may contribute to the distance traveled. The effect that limited feeding activities [e.g., stoneflies feeding on young leaves and buds or on algae on tree trunks (Frison 1935; Harper and Stewart 1984), midges and caddisflies feeding on nectar or honeydew (Burt and others 1986)] may have on dispersal distance has not been examined.

The above activities contribute to the distribution and abundance of adults in the riparian zone. In a recent study of the distribution of adult aquatic insects in the mixed evergreen forest adjacent to a third-order

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California stream (Big Sulphur Creek, Sonoma Co.), we found that the abundance of adult aquatic insects was greatest near the stream and decreased as distance from the stream increased (fig. 1). The rate of decrease in abundance varied among species. For example, two species of caddisflies, *G. nigricula* and *Helicopsyche borealis* (Hagen) (Trichoptera: Helicopsychidae), were very abundant in the trees next to the stream. However, *H. borealis* was almost absent 40 meters from the stream whereas *G. nigricula* was still common 150 meters from the stream (Jackson and Resh, in press). By flying more than 50 meters from the stream, adult aquatic insects would be outside of most riparian buffer zones that are recommended to protect water quality and aquatic life in streams (Brinson and others 1981).

Within the forest canopy, most of the species examined in the Big Sulphur Creek study exhibited one of two distribution patterns: adults were either equally abundant at all heights examined (2, 5, 8 meters above the ground) or they were more abundant near the tree tops (8 meters) than at the tree bases (2 meters). Only one species, an undescribed species of the caddisfly *Ochrotrichia* (Trichoptera: Hydroptilidae), was more abundant near the tree bases than the tree tops (Jackson and Resh, in press).

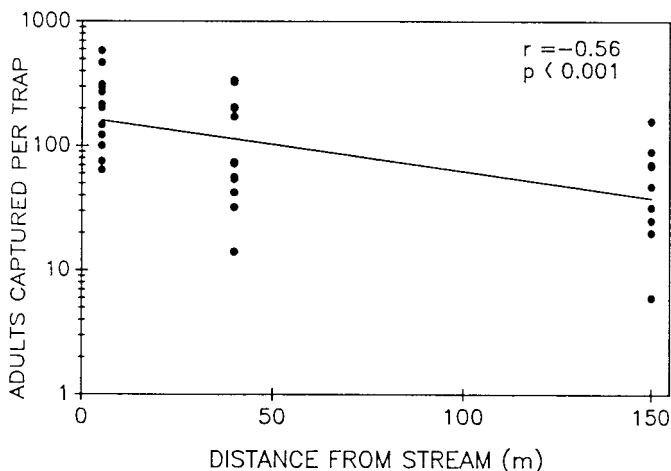


Figure 1— Simple linear regression between distance from the stream and total number of adult aquatic insects captured (logarithmic scale) in sticky traps set in the mixed evergreen forest adjacent to Big Sulphur Creek.

Ecological Role of Adult Aquatic Insects

Various studies have shown that between 1 percent and 57 percent of the biomass produced by immature aquatic insects (i.e., secondary production of aquatic insects) emerges from the aquatic system in the form of adult insects (see Jackson and Fisher 1986 for review). Because many of these adults die in the riparian zone, much of this biomass does not return to the aquatic habitat (Jackson and Fisher 1986). This export of biomass reduces the organic matter and nutrients that are available to aquatic insectivores (e.g., fish, amphibians, other macroinvertebrates) and increases organic matter and nutrients that are available to riparian insectivores (e.g., birds, bats). For riparian insectivores, the importance of this export of aquatic biomass depends on the abundance of adult aquatic insects as prey relative to the abundance of terrestrial insects as prey.

Adult aquatic insects represented 37 percent of total arthropod numbers and 25 percent of total arthropod biomass captured by sticky traps placed in trees 5 meters from Big Sulphur Creek; 150 meters from the stream, adult aquatic insects still represented 15 percent of numbers and 11 percent of biomass (Jackson and Resh, in press). Adult aquatic insects are often major components in the diets of riparian birds (e.g., Clark 1984; Blancher and others 1987) and bats (e.g., Herd and Fenton 1983; Swift and others 1985), which suggests that this aquatic-terrestrial interaction may have contributed to the abundant insectivore faunas that characterize riparian systems. The potential importance of adult aquatic insects to riparian insectivores is greatest in arid regions such as California and Arizona (e.g., Gaines 1977; Brinson and others 1981; Clark 1984) because terrestrial insects may be less abundant in upland areas.

Implications for Management of Riparian Zones

The above examples illustrate the importance of the interaction between adult aquatic insects and the riparian zone. However, adults have not been considered in the management of riparian systems. Modifications of the riparian zone can directly affect adult aquatic insects by interfering with the reproductive activities of adults [e.g., swarm or oviposition markers are lost (Statzner 1977)] or by changing abiotic (e.g., air temperature) or biotic (e.g., insectivore density) conditions that adults are exposed to in the riparian zone. Indirect effects can include changes in the survival and growth of the immature stages of aquatic insects (i.e., those that occur

in the stream), which in turn affects the abundance of adult aquatic insects in the riparian zone.

This array of direct and indirect effects increases the complexity of management decisions. For example, opening the stream canopy can increase the production of the immature stages of aquatic insects in the stream. As a result, immatures would be more available as prey for stream insectivores, such as trout (Hawkins and others 1983), and adults would be more available as prey for riparian insectivores, such as birds and bats. However, such a modification of the riparian zone may actually have a negative effect on stream biota because other essential stream parameters (e.g., water temperature) would also change (Hawkins and others 1983). Birds and bats may be adversely affected as well if the survival and reproductive success of adult aquatic insects decrease (and consequently numbers in subsequent generations decrease) because of modification of the riparian zone.

Factors that affect the distribution, abundance, and function of the immature stages of aquatic insects in aquatic systems have been examined extensively (Resh and Rosenberg 1984).

In contrast, comparable information is not available for the adult stages. If management plans for riparian zones are to be complete, further studies that elucidate the role of adult aquatic insects in riparian systems are needed.

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