
Benthic Community Structure and Invertebrate Drift in a Pacific Island Stream, Kosrae, Micronesia¹

ABSTRACT

Tropical Pacific island streams have poorly understood communities that deserve scientific attention. We examined benthic macroinvertebrates and fishes of the Inem River on Kosrae, Federated States of Micronesia. Larval chironomids, lepidopterans, odonates, and freshwater shrimps dominated the benthos and drift. Diel periodicity in drift was not evident. Nine fishes, two shrimps, and one snail species were identified. Kosrae's stream fauna appears even more depauperate than other Pacific high islands, possible due to its extreme isolation.

Key words: amphidromy; freshwater shrimps; migration; Oceania; tropical rivers; volcanic high-island.

PERENNIAL STREAMS DRAINING MANY of the geologically young, volcanic high-islands of the Pacific Ocean have extremely depauperate communities that are very poorly understood (Resh & de Szalay 1995, Craig *et al.* 2001). Isolation from other island systems and continental landmasses (often involving distances of hundreds of kilometers) results in stream communities that are dominated by marine-derived, diadromous taxa (*i.e.*, fishes, shrimps, and snails; Resh *et al.* 1992). In contrast to continental streams, aquatic insects are not major components of Pacific island stream communities, and insect assemblages are composed only of those species able to colonize over huge distances (Resh & de Szalay 1995). Despite being of great biogeographic and ecological interest, Pacific island streams have received comparatively little scientific attention with the exception of Hawaii (Kido 1996, Zink *et al.* 1996, Englund & Polhemus 2001). Improved understanding of their community structure and invertebrate drift patterns could benefit ecological theory (Craig *et al.* 2001) and guide regional water resource management (Benstead *et al.* 1999).

In October 2000, we conducted a short-term study of the Inem River on Kosrae, located in the eastern Caroline Islands in the equatorial western Pacific Ocean (5°16'–5°22'N, 162°54'–163°02'E). Kosrae is the easternmost island-state in the Federated States of Micronesia, and is a small (112 km²) volcanic high-island (maximum elevation 629 m) between 1.2 and 2.6 million years old (Keating *et al.* 1984). Annual mean temperature is 27°C and average annual rainfall ranges from 5000 mm at the coast to 7500 mm in the interior (Whitesell *et al.* 1986). Marked seasonality in temperature and rainfall is not evident on Kosrae (Ewel *et al.* 1998). The Inem is a small (third order) stream that flows into the Pacific on Kosrae's eastern side. Its catchment vegetation consists of undisturbed upland forest (dominated by the canopy tree *Camptosperma brevipetiolata*), with some agroforestry at lower elevations (Whitesell *et al.* 1986). Our study site was a 100-m reach situated at *ca* 20 m elevation on the main stem of the stream. Riparian vegetation was dominated by *C. brevipetiolata* and *Hibiscus tiliaceus*. The channel was *ca* 7 m wide and the substratum was mostly cobble, with some boulders, gravel, and sand. While intense

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precipitation and associated spates are common on Kosrae, no large flow disturbances occurred within 24 hours of sampling.

We sampled the benthic invertebrate community by taking Surber samples on one date ($N = 8$; mesh 363 μm), which were preserved immediately in 70 percent ethanol. We also sampled invertebrate drift over three 24-hour periods in order to further characterize the invertebrate community and to examine the drift patterns of amphidromous freshwater shrimp species and other invertebrates (Pringle & Ramírez 1998). Diel patterns of drift were determined by sampling every three hours from 0900 to 0600 h. During the study, sunrise and sunset for the island were 0653–0654 and 1850–1856 h, respectively. Samples were collected by placing two drift nets (opening dimensions, 300 \times 450 mm; mesh, 363 μm) in mid-channel positions for timed periods of 3.5 to 12 minutes depending on flow conditions. Nets were removed from the stream before clogging caused backwelling. Depth and flow velocity were measured to calculate the volume of water sampled. Depth was measured to the nearest 5 mm. Flow was measured to the nearest 0.01 m/sec at five points directly in front of the net using a Marsh-McBirney® flow meter. Drift samples were preserved immediately in 70 percent ethanol. Discharge was never observed to change appreciably during any 24-hour period.

Fishes and freshwater shrimps present at the site were recorded using a variety of techniques. Fishes were observed and identified by snorkeling, or sampled by angling, minnow traps, or seine net. Small gobiids were corralled into Surber samplers by snorkelers. Shrimps were caught in baited minnow traps or collected by hand. Representative material for identification was preserved in 70 percent ethanol.

Benthic and drift samples were transported to the University of Georgia (U.S.A.), where they were stained with rose bengal before being picked of invertebrates. All macroinvertebrates were identified to the lowest possible taxonomic level under a stereomicroscope. Mean drift densities (number of individuals/100m³) at each time were calculated by dividing the number of animals found in each sample by the volume of water sampled and multiplying by 100. To assess diel periodicity of drift, night:day drift ratios of dominant taxa were calculated by dividing mean day drift density (samples taken from 0900 to 1500 h) by mean night drift density (1800–0600 h samples) over the three 24-hour periods. We included the 1800 sample in the nocturnal period because it became dark at the site at this time due to the steep valley slopes and the eastern aspect of the catchment.

The benthic invertebrate community of the Inem River was extremely depauperate (Fig. 1). Densities were also very low compared to most continental streams. Insects were represented only by larval Chironomidae, larval Lepidoptera (Pyralidae), and a few small Odonata nymphs. Although chironomids were not identified beyond family in this study, we have collected the cosmopolitan genera *Chironomus* and *Tanytarsus* from a nearby stream on Kosrae. The only other major components of the benthos found in Surber samples were oligochaete annelids and small atyid shrimps (Fig. 1).

Drift samples contained more taxa. Dominant components of stream drift included Chironomidae and Lepidoptera (Pyralidae), and first-stage larvae of freshwater shrimps (Fig. 2). Also present were low numbers of tadpoles (presumably of the introduced cane toad *Bufo marinus*), atyid shrimps, juvenile *Macrobrachium* shrimps, oligochaete and polychaete annelids, ostracods, and odonates. Drift samples also contained Collembola, emerging chironomid pupae, and terrestrial insects (mostly ants). Pronounced diel drift periodicity was not found in any major group (Fig. 2). There was some evidence for periodicity in Chironomidae and Lepidoptera, which had consistently higher drift densities at night (mean night:day drift ratio for Chironomidae: 2.09, range 1.37–3.96; mean drift ratio for Lepidoptera: 1.46, range 1.05–1.85). Larval freshwater shrimps showed no pronounced diel periodicity (mean night:day drift ratio: 1.11, range 0.24–5.23).

Fishes recorded at the site were *Kuhlia rupestris*, *K. marginata* (Kuhliidae), *Stenogobius* sp., *Stiphodon pelewensis*, *Redigobius bikolanus*, *Glossogobius celebius* (all Gobiidae), *Anguilla marmorata* (Anguillidae), *Caranx sexfasciatus* (Carangidae), and *Lutjanus argentimaculatus* (Lutjanidae). The last two species are marine fishes that were only present as juveniles. Shrimp species found were *Macrobrachium* lar (Palaeomonidae), *Atyoida pilipes*, and *Caridina serratiostris* (both Atyidae). The large snail *Neritina pulligera* was also found at the site.

Previous studies have found similarly low species richness and density of benthic macroinvertebrates in Pacific island streams. These communities are often dominated by atyid and palaemonid shrimps, snails, and oligochaetes (Barnes & Shiozawa 1985, Resh *et al.* 1990). The Inem's benthic insect community had particularly low taxonomic richness, consisting only of Chironomidae, Pyralidae (Lepidop-

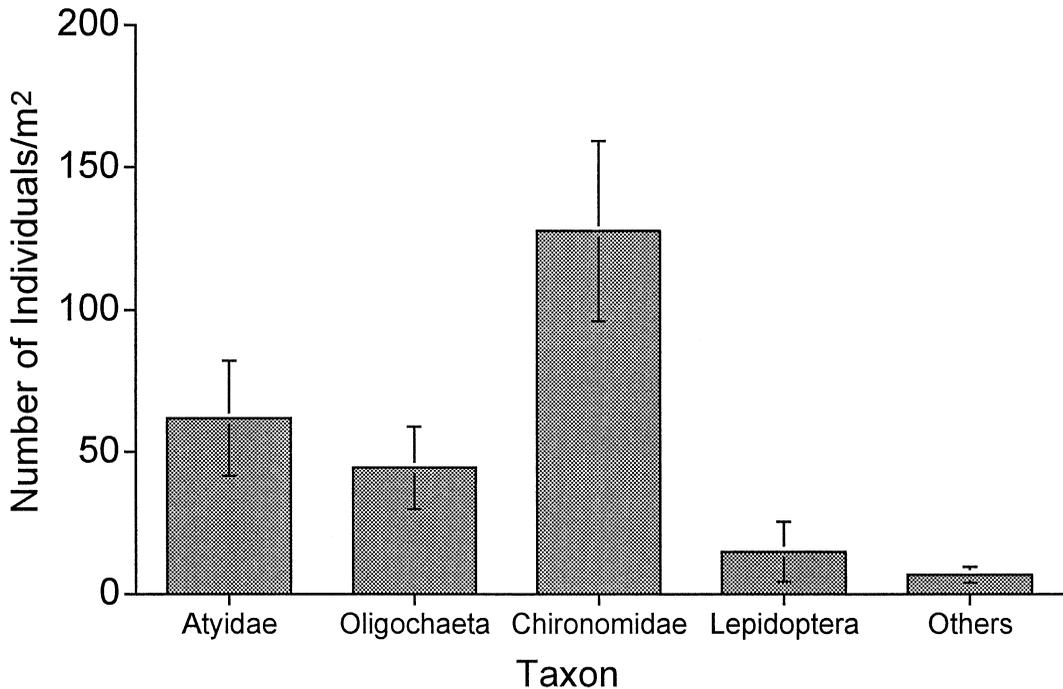


FIGURE 1. Densities of benthic macroinvertebrates in the Inem River, Kosrae, Federated States of Micronesia, October 2000. The category “Others” included polychaete annelids, Odonata, and unidentified invertebrates. Data are means \pm 1 SE.

tera), and Odonata. Islands farther to the west and south also harbor these cosmopolitan taxa, but other groups are also found (e.g., Trichoptera and Diptera: Simuliidae; Maciolek & Ford 1987; Resh *et al.* 1990, 1992). These results suggest that Kosrae’s benthic stream communities are species-poor even by Pacific island standards, possibly due to the comparative isolation of the island and its distance to sources of colonists; however, more thorough sampling including water surface and splash-zone habitats should be conducted before any firm conclusions are made.

We found no evidence for pronounced diel periodicity in any major component of invertebrate drift. In the only other published study of stream drift from the Pacific region (Hawaii), Barnes and Shiozawa (1985) found that only juvenile atyid shrimps and larvae of an introduced caddisfly (Trichoptera) exhibited diel drift periodicity, while other groups (Turbellaria, Oligochaeta, Chironomidae, and harpacticoid Copepoda) showed no patterns. The Inem River contains abundant fishes that feed in the water column (*Kuhlia* spp.) and, based on the risk-of-predation hypothesis (Flecker 1992), we would have expected invertebrates to exhibit predominantly nocturnal drift. We found weakly nocturnal drift in the two dominant insect taxa, but this could have been a consequence either of behavioral periodicity or of diurnal predation by fishes. Freshwater shrimp larvae often display nocturnal migratory drift (March *et al.* 1998, Ramírez & Pringle 2001). Although larval shrimp drift in the Inem consistently declined during the day and usually increased at dusk, mean night:day drift ratio was *ca* 1:1. Variability among dates (and low drift densities in general) may have obscured any diel pattern in larval shrimp drift.

The Inem’s macroconsumer community was typical of Pacific high-island streams. It was dominated by cosmopolitan amphidromous species and juvenile marine fishes common to the Indo–West Pacific region. With the exception of *Stenogobius* sp. (Gobiidae) and *C. serratiostris* (Atyidae), all the shrimps, snails, and fishes found in the Inem were also recorded from neighboring Pohnpei by Maciolek and Ford (1987), Buden, Lynch, Short, and Leberer (2001), and Buden, Lynch, and Watson (2001). Both *Stenogobius* and *C. serratiostris* are lowland taxa (Marquet 1991, Nelson *et al.* 1997) that may not have been present at the relatively high Pohnpei sites of these surveys.

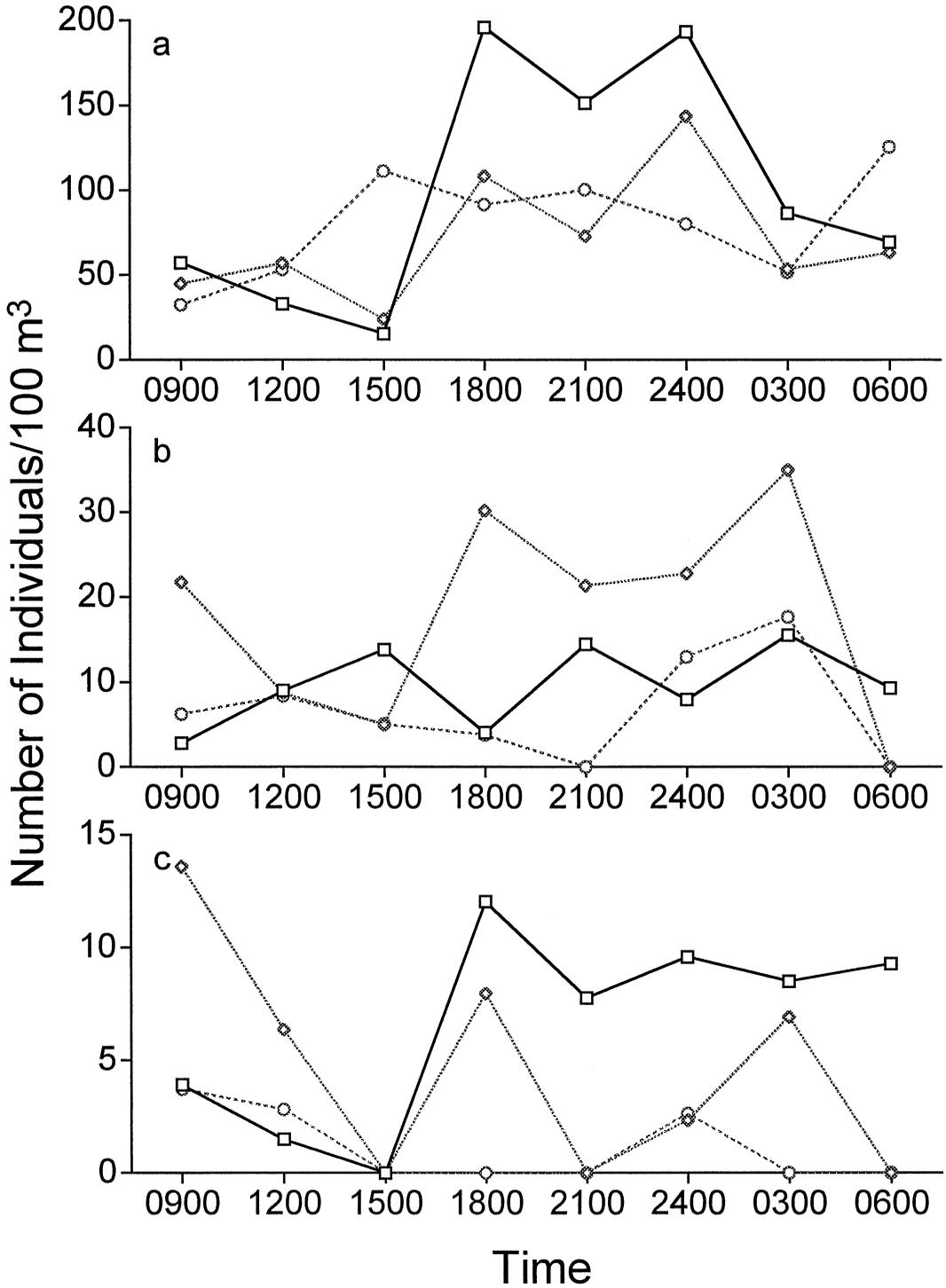


FIGURE 2. Mean drift densities of (a) Chironomidae, (b) Lepidoptera, and (c) first-stage freshwater shrimp larvae in the Inem River, Kosrae, on 10–11 (squares), 19–20 (diamonds), and 26–27 (circles) October 2000.

This study represents the first published ecological data from Kosrae's stream ecosystems. While benthic community structure in the Inem River was similar to that recorded in the few studies conducted on neighboring islands, it differed from those of Hawaii, from where much of our understanding of Pacific island stream ecology is derived. Hawaii's streams have been greatly modified by water transfers, changes in catchment vegetation, and exotic species introductions (*e.g.*, at least 31 exotic species of fish; Resh & de Szalay 1995). In contrast, Kosrae's streams contain no exotic species (with the exception of *B. marinus* tadpoles) and are relatively unaffected by other human-induced changes. As such, data from the Inem River provide a reference for undisturbed conditions in high-island streams of Micronesia and the greater Pacific region. They also highlight the value of such taxonomically depauperate streams for comparative ecological studies, both of species function in ecosystem processes and of exotic species impacts. Finally, such data are crucial for guiding future resource management on these small isolated islands.

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