

**Etho-ecological observations of a guppy population  
(*Poecilia reticulata* Peters, 1859) in a thermally  
polluted stream in Germany**

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A population of the guppy (*Poecilia reticulata*) living outside of tropical or subtropical regions is described. Its habitat is located near Cologne, Germany, in a thermally polluted stream, and it probably originates from specimens kept in aquaria. Various water parameters and first results of biocoenotic and etho-ecological examinations are reported in an overview of a study in its early stages.

Key words: abundance; behaviour; biocoenosis; guppy; phenotype; predatory pressure.

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## INTRODUCTION

The guppy (*Poecilia reticulata* Peters), which is endemic to northeastern South America (Venezuela, Trinidad & Tobago, British Guyana, Surinam), was spread by humans to many other subtropical and tropical countries worldwide. The fish were often established for mosquito control. Because of its enormous ecological plasticity the *Poecilia* species rapidly developed permanent populations at many sites (Welcomme, 1981; Kempkes, 2002). At the same time native species were displaced.

Even in the temperate zone populations are known, but they can only exist under conditions which ensure a water temperature within the range compatible to the species. Such habitats are reported in Ijmuiden, northern Netherlands (Doornenbal, 1968), and in several locations in Germany: in the Saarland (Becker, 1983), the Spreewald forest near Cottbus (Funda, 1979; Engelhardt, 1993; Paepke & Heym, 2002); and the northern Ruhr area (Meier, verbal notification).

Another such temperate zone guppy population is found in the German Rhine region northwest of Cologne. The habitat is located in the upper reaches of a stream, the Gillbach, within the municipal boundaries of Bergheim, near to the village of Niederaussem (Fig. 1). Müllenholz (1978) was the first to report on this population. As early as 1972 Rose (verbal notification) netted guppies here and kept them in an aquarium. Because the Gillbach population of *P. reticulata* has existed for at least 36 years, the species is to be regarded as established (see also Gebhardt *et al.*, 1996; Kinzelbach, 1972).

## MATERIALS AND METHODS

Informal observations and documentation of the guppy population and its habitat in the Gillbach began in the year 2000 and led to a formal study beginning in 2007. This study involves measurement and interpretation of various water parameters (Table I), the identification of species, particularly phyto-benthos, benthic invertebrate fauna and fish fauna, regular ethological observations, evaluation of predatory pressure, estimation of guppy abundance and quantification of sexes and male phenotypes.

The qualitative and quantitative composition of the fish fauna is evaluated by electric fishing (Table II). Other fauna is identified by field observation, benthic sampling and microscopical analyses. Snorkelling is undertaken as a practical means of performing ethological observation and population studies.

Microscopical analyses of the digestive tracts of predatory species and of guppy faeces have been initiated to obtain information about predatory pressure and feeding behaviour.

## STUDY SITE

The Gillbach stream has been modified by man (Fig. 2). The banks and the bed have been stabilized with large rocks. As the stream is almost completely charged by cooling water from a power plant, the water outlet of the plant forms the “source” of the Gillbach. The average discharge is about 0.5 m<sup>3</sup>/s, but can momentarily fluctuate between 0.2 and 0.7 m<sup>3</sup>/s within a day.

Measurements and field observations have been started at two monitoring points. The first monitoring point is situated directly at the power plant outlet. The second is located 300 m further downstream.

## RESULTS

### WATER QUALITY

The water of the Gillbach is only slightly polluted by organic material and is rich in oxygen and ions of calcium, magnesium, chloride and sulphate (Table I). The ions result in high conductivity of the water. The pH-value is slightly alkaline. Water temperature ranges from 16 to 27 °C year-round.

### BIOCOENOSIS

Apart from endemic species and guppies several other non-native animals and plants are present in the Gillbach. In comparison to other streams in the same region invertebrates in the upper reaches of the Gillbach are in low abundance. Studies conducted by the Erftverband, the local water management association, document chironomid larvae, numerous red-rimmed

melanias (*Melanoides tuberculatus*), the endemic tadpole snail *Physa acuta* and various caddies fly larvae of the genera *Hydroptila* and *Polycentropus*. Phytobenthos is dominantly represented by diatoms and the green algae *Cladophora glomerata*, but there are also blue-green algae of the genus *Oscillatoria* and the rhodophyte *Compsopogon hookeri*, which originates from Asia. Notable stocks of the (sub)tropical aquatic plant *Vallisneria spiralis* attract attention about 200 m below monitoring point 1.

In September 2007 nine fish species in all were detected by electric fishing (Table II). Several Convicts (*Amatitlania nigrofasciata* Günther) and a blue tilapia (*Oreochromis aureus* Steindachner) were observed at another time. The cichlids stayed close to the adult guppies, but did not hunt them, whereas chubs (*Leuciscus cephalus* L.) attacked the schools of guppies. The success of such attacks could not be quantified. A kingfisher (*Alcedo atthis*) started hunting for small fish from a raised point.

As for direct human influence, it is known that local residents bring and remove fishes from the stream at varying intervals. In December 2007 children were seen catching several *Ancistrus* catfish. This species had not been detected by electric fishing because these fish inhabit the interstices of stones.

#### GUPPY ABUNDANCE

In September 2007 a group of about thirty males, a similar number of females and numerous newborns were found at monitoring point 1. However, by contrast, in November 2007 and in January 2008 only a few adult and subadult guppies and no newborns could be spotted at this point.

At monitoring point 2 numerous guppies were also found in September, but only four juveniles at the age of a few days were detected in November. In January only a few guppies of various ages could be seen.

#### GUPPY PHENOTYPES

While around 80% of the males examined had no extension of the caudal fin rays, about 10% had a dorsal extension of the outer caudal fin rays, and another 10% a dorsal and ventral extension. About 80% of the males showed colour patterns, which could be an expression of

the *Iridescens* gene (Winge 1927). Roughly every fourth male in the population had a white spot in the upper area of the caudal fin. The females did not show any colour pattern and the fins were hyaline. No external symptoms of disease could be detected in the surveyed sub-adult or adult guppies. Ten juveniles which were caught had relatively dark bodies. Their clamped fins indicated a suboptimal state of health.

## GUPPY BEHAVIOUR

At no time was there agonistic behaviour among the guppies. There was also no apparent anti-predator behaviour, nor a watchful attitude towards predators. Juveniles showed a distinct swarming behaviour, which continued during changes of position. During winter the adults were hidden between branches and stones, and there was no detectable courtship behaviour.

## COURTSHIP

Details were observed by means of snorkelling done in September 2007. Courtship behaviour was found to be equivalent to the patterns of behaviour described by Clark & Aronson (1951) and Baerends *et al.* (1955), though courtship almost never started with the classic initiation. Instead the males immediately courted the females in patterns described by Baerends *et al.* (1955) as belonging to the main phase of courtship. Males often showed the sigmoid display after discovering and approaching a female. Sigmoid display took only a short time. Then the male briefly followed the courted female and, turning the gonopodium forward, tried to copulate from behind. The observations revealed that such sneak copulation is the most frequent reproductive strategy. This was even visible in places which offered protection from predatory pressure from adult chubs.

There was no receptive or cooperative behaviour of the females. Their habitus indicated that they were pregnant, which could explain the non-receptive behaviour. Studies of non-pregnant females are necessary to determine if they are receptive in this case.

During the on-site study neither snorkelling nor observation from above revealed the forcible turning out of the gonopodium reported by Leo & Greven (1999).

## DISCUSSION

Recent observations validate previous reports that numerous non-native species, including guppies, live alongside indigenous ones in the Gillbach. The most important predators of the guppies are probably the larger indigenous chubs and eels, although catfish and tilapias may also hunt them. Though a first stomach examination of a sub-adult chub did not indicate predation upon guppies, it is known that chubs increasingly tend to piscivore feeding as they become older. The precise role of the chubs as guppy predators requires further study, particularly of older individuals. The mouth and head morphology of the eels (*Anguilla anguilla* L.) which were detected shows that these are piscivore. Their exact impact on the guppy population is still unknown. The Catfish *Clarias batrachus* L. is known as a piscivore predator, too, and the omnivorous tilapias (*O. aureus*) are also assumed to hunt guppies occasionally. Observations indicate that the convicts do not hunt guppies.

The guppies' behaviour clearly shows that they have to withstand substantial predatory pressure in the Gillbach. If larger fishes, meaning potential predators, are present, the guppies prefer to stay among branches and between the large stones. The juvenile and sub-adult guppies primarily stay in the shallow water near the banks, as do the conspecifics in their natural range in Venezuela (Kempkes, verbal notification). Courtship in the "open water", which means above protecting stones and away from branches, more likely occurs when chubs or tilapias are absent. Furthermore, male guppies start courtship without patterns of initiation, which is also assumed to be a result of predatory pressure.

Studying guppies in their natural range, Magurran & Seghers (1990), Dugatkin (1992), Dugatkin & Godin (1992) and Godin & Davis (1995a,b) report on a particular anti-predator strategy. They describe a state of alertness in which guppies observe predators to identify their intent. However, in the presence of chubs the Gillbach guppies, apart from hiding, did not show such behaviour. Magurran et al. also reported that competing males try to get close to a predator, e.g. *Crenicichla alta* (Eigenmann), to impress a female. Such a pattern also could not be detected in the Gillbach. Perhaps the development of a stable relation between prey fish and predators is necessary within an evolutionary process to generate such patterns, or the chubs inhibit the development of such patterns by their fast, hectic manner of swimming.

Faecal examinations in winter show that guppies in the Gillbach subsist on benthic algae. At present it is uncertain to what extent the guppies also satisfy their energy requirements through detritus or organic matter adsorbed on mineral particles.

Observations made since the year 2000 indicate maximum abundance of individuals in late summer/early autumn. In the winter period the population consists of fewer individuals than in summer. Precise quantification is planned in the current study.

In the Gillbach the variety and abundance of species which mainly originate from tropical countries is accounted for by haphazard introductions by humans over decades. First, aquarists are assumed to dispose of superfluous pets in this manner. Other non-native fishes are presumed to originate from aquaculture which was practised in the vicinity until 2000. Residents who collect guppies and presumably bring them back to the stream are considered as an “anthropogenic factor”, but their impact on the population is assumed to be small.

The guppy population in the upper reaches of the Gillbach is an interesting subject for studies which otherwise could only be done in (sub)tropical regions. Observations of behaviour, feeding, predatory pressure and development of the population through the annual cycle will be continued.

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