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Effects of seasonal acclimatization on temperature dependence of cardiac excitability in the roach, Rutilus rutilus.

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Abstract

Temperature sensitivity of electrical excitability is a potential limiting factor for performance level and thermal tolerance of excitable tissues in ectothermic animals. To test whether the rate and rhythm of the heart acclimatize to seasonal temperature changes, thermal sensitivity of cardiac excitation in a eurythermal teleost, the roach (Rutilus rutilus), was examined. Excitability of the heart was determined from in vivo electrocardiograms and in vitro microelectrode recordings of action potentials (APs) from winter and summer roach acclimatized to 4 and 18°C, respectively. Under heat ramps (3°C h(-1)), starting from the acclimatization temperatures of the fish, heart rate increased to maximum values of 78±5 beats min(-1) (at 19.8±0.5°C) and 150±7 beats min(-1) (at 28.1±0.5°C) for winter and summer roach, respectively, and then declined in both groups. Below 20°C, heart rate was significantly higher in winter than in summer roach ($P<0.05$), indicating positive thermal compensation. Cardiac arrhythmias appeared with rising temperature as missing QRS complexes, increase in variability of heart rate, episodes of atrial tachycardia, ventricular bradycardia and complete cessation of the heartbeat (asystole) in both winter and summer roach. Unlike winter roach, atrial APs of summer roach had a distinct early repolarization phase, which appeared as shorter durations of atrial AP at 10% and 20% repolarization levels in comparison to winter roach ($P<0.05$). In contrast, seasonal acclimatization had only subtle effects on ventricular AP characteristics. Plasticity of cardiac excitation appears to be necessary for seasonal improvements in performance level and thermal resilience of the roach heart.

KEYWORDS: Action potential; Cardiac arrhythmias; Electrocardiogram; Eurythermal fish

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