

In a recently submitted paper the transition of asexual blood stages of *Plasmodium falciparum* to Gametocytes is modelled. Thereby, 262 individual parasite and the corresponding gametocyte time series are evaluated. On the basis of the observed asexual parasitaemias the expected gametocyte courses are evaluated and compared with the observed ones in order to estimate some biologically important parameters. Please see the next page for more information on that paper.

It goes without saying that it is impossible to present all 262 fits in a journal. However, to give the readers full access to all graphs we present them on this web page. Following pages contain 262 individual fits each of them containing the observed asexual parasitaemia, the observed gametocytaemia and the expected gametocyte curves fitted by means of a maximum likelihood procedure. The model assumptions are in compliance with the "Gompertz mortality" and an additional "parasite-mediated" mortality of the gametocytes as described in the paper. Other fits that rest on others than Gompertz mortalities are not shown because they turn out to having inferior "goodness-of-fits". Please confer the paper for a detailed description.

Modelling the Transition of Asexual Blood Stages of
Plasmodium falciparum to Gametocytes

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² World Health Organisation, retired

³ Centers for Disease Control and Prevention,
U.S. Public Health Service,
Department of Health and Human Services,
Atlanta, GA.

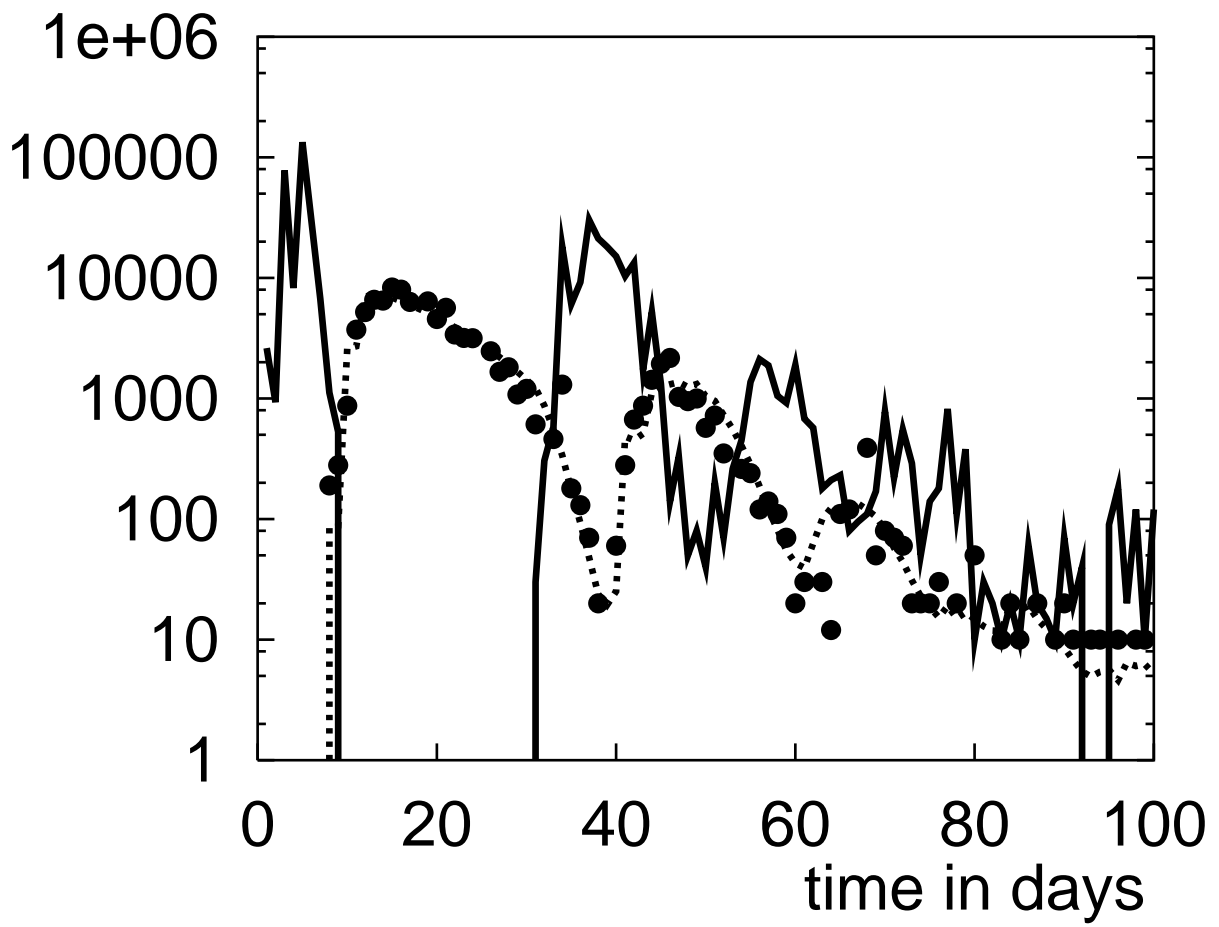
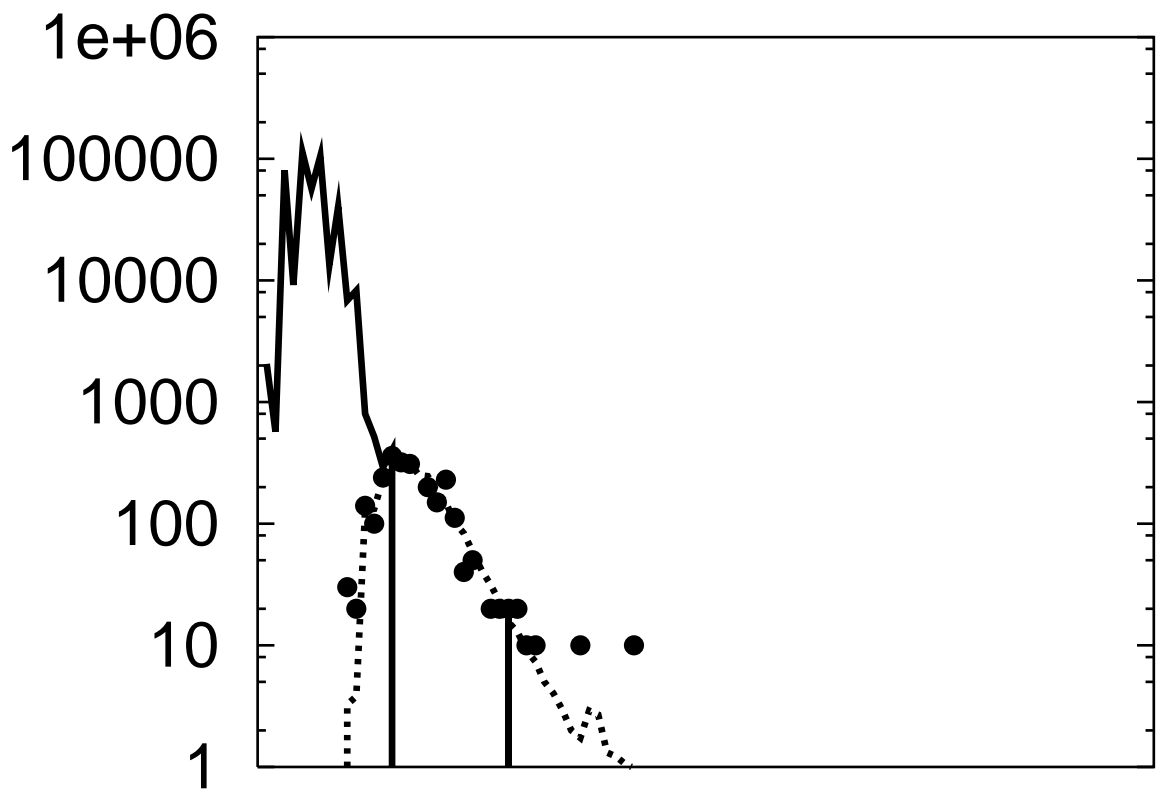
⁴ U.S. Public Health Service, retired

October 5, 1999

Abstract

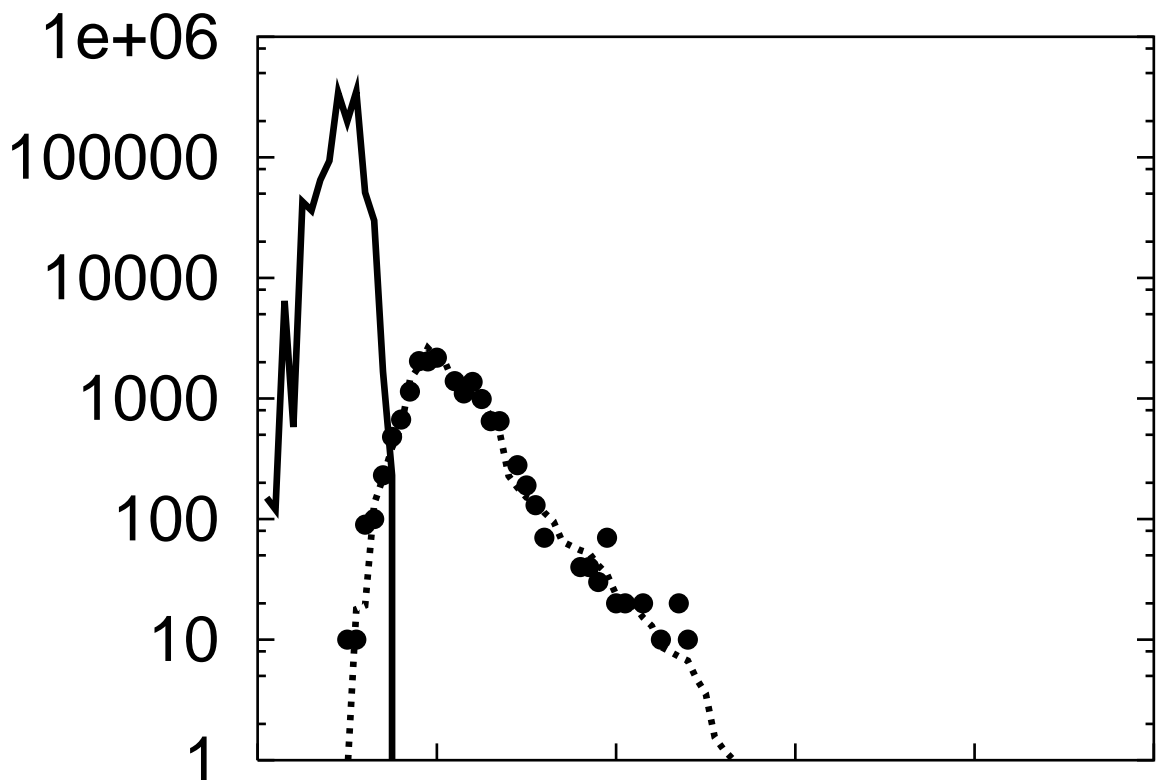
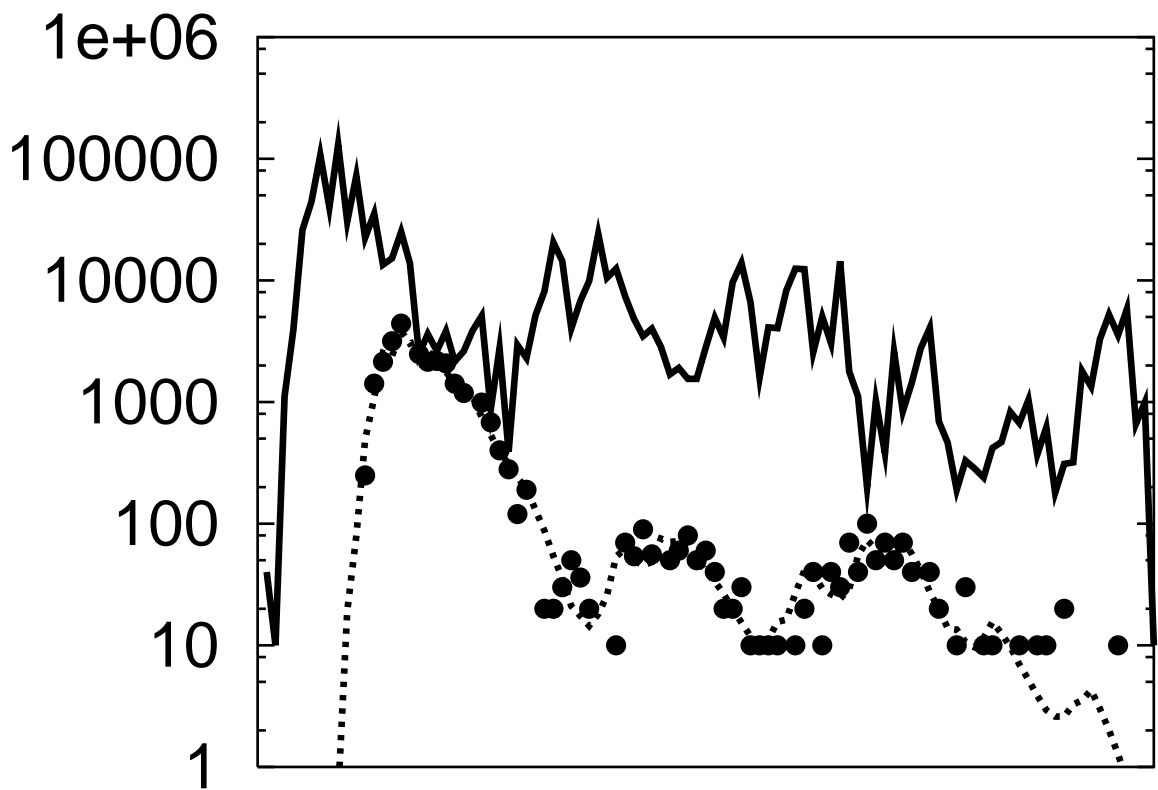
In this paper, we investigate the transition of asexual blood stages of *P. falciparum* to gametocytes. The study is based on daily data, collected from 262 individual courses of parasitaemia. We propose several mathematical models that follow biological reasoning. The models are fitted with maximum likelihood and are compared with each other. The models differ in the assumptions made about the mortality of circulating gametocytes and about the transition rate of the asexual parasites. Gametocyte mortality is modelled as being (i) constant over time, (ii) linearly increasing over time, (iii) linearly increasing over gametocyte age, and (iv) exponentially increasing over gametocyte age, respectively. The transition rate is either kept constant per patient or piecewise constant within intervals that correspond to waves of asexual parasitaemia which are assumed to be caused by different Pf_{emp1} -variants. According to likelihood ratio tests, the models with age-dependent mortality rate and wave-dependent transition rates are superior to the models with constant transition rate and/or constant or time-dependent mortality rate. The best fits are reached for models with exponentially increasing (Gompertz-type) mortality. Furthermore, an impact of high asexual parasite densities on the survival of gametocytes, interpreted as a cytokine-mediated effect, is evident in some cases.

parasites per μl blood



asex. parasites —
observ. gameto. •
expect gameto. ·····

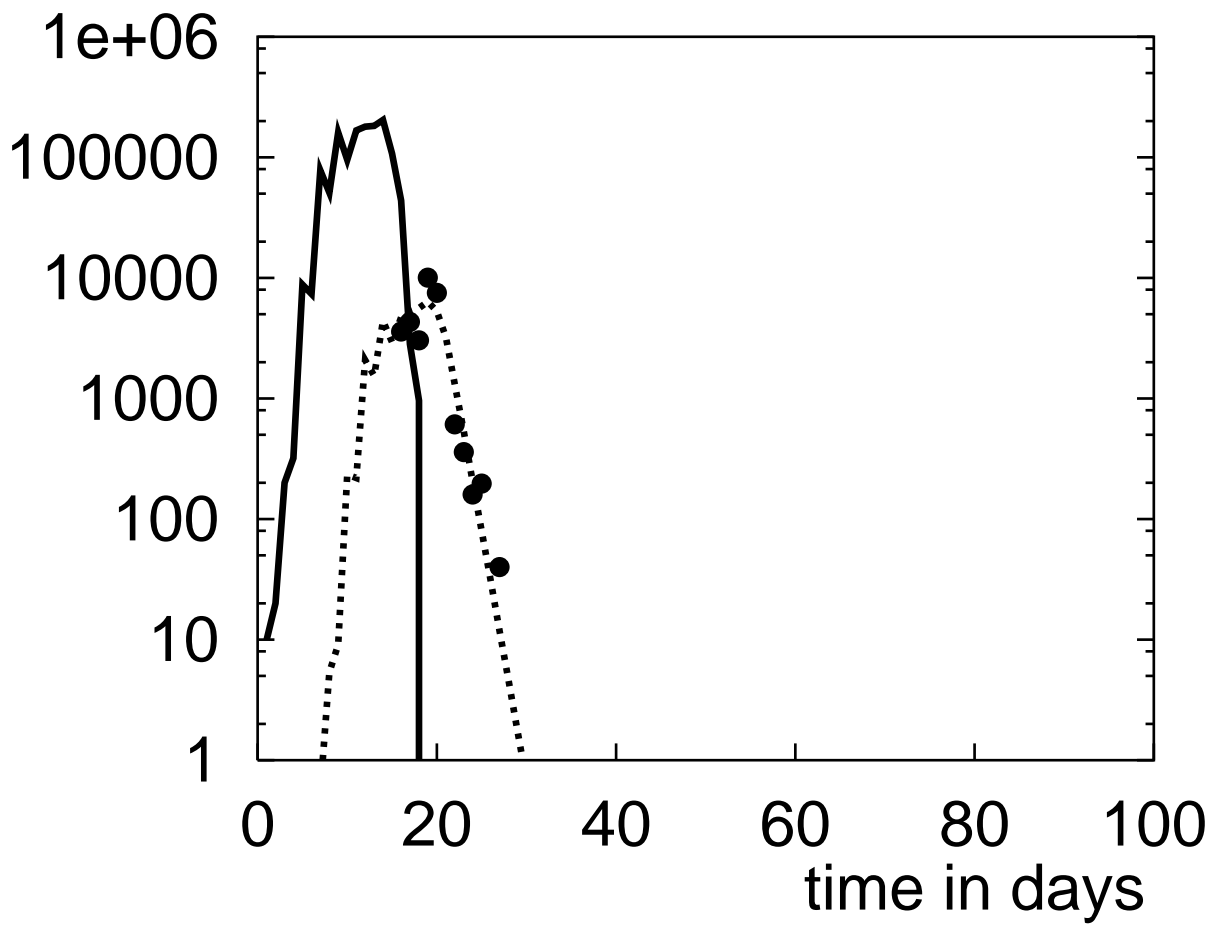
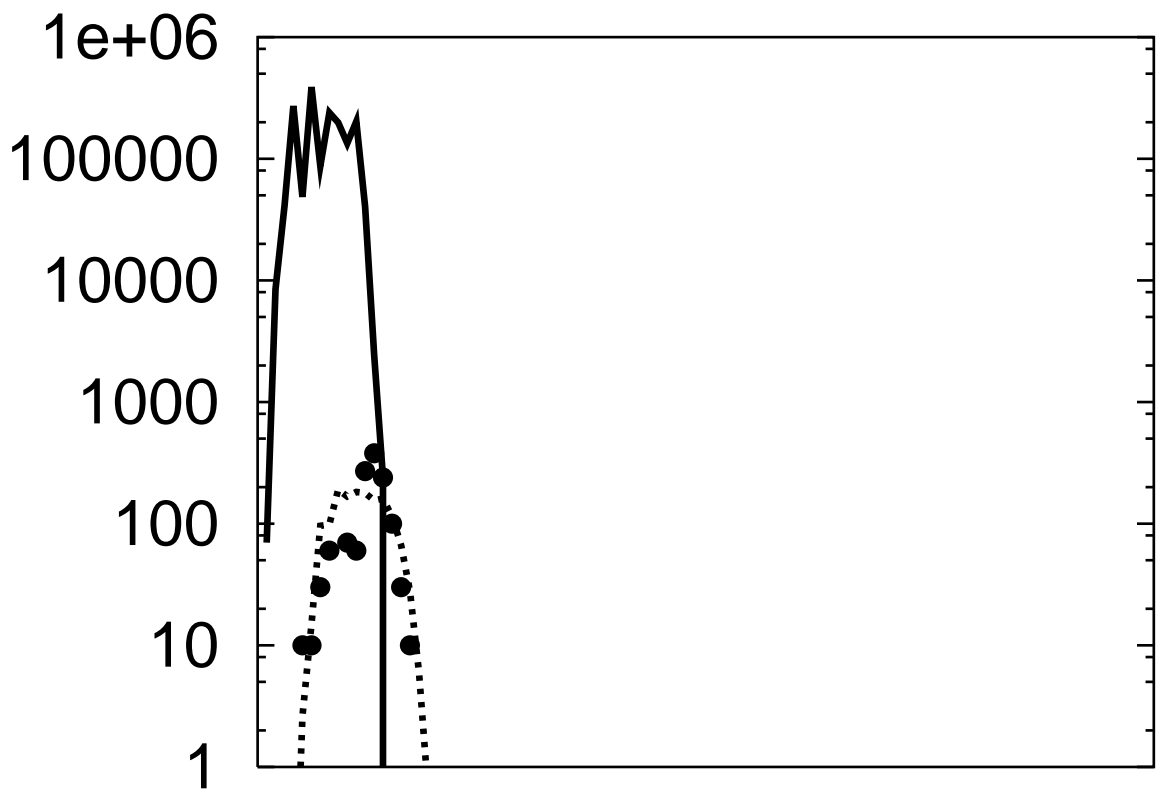
parasites per μl blood



0 20 40 60 80 100
time in days

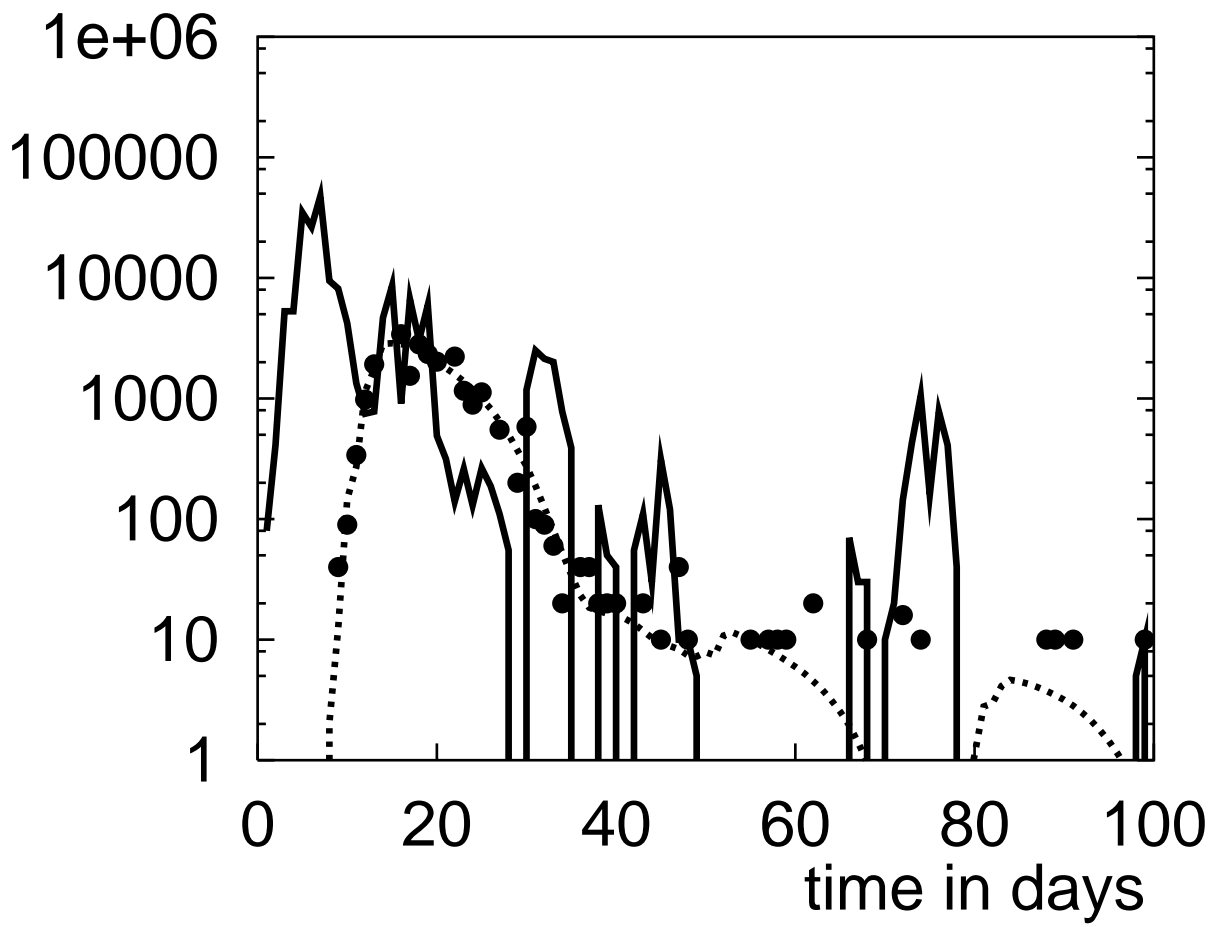
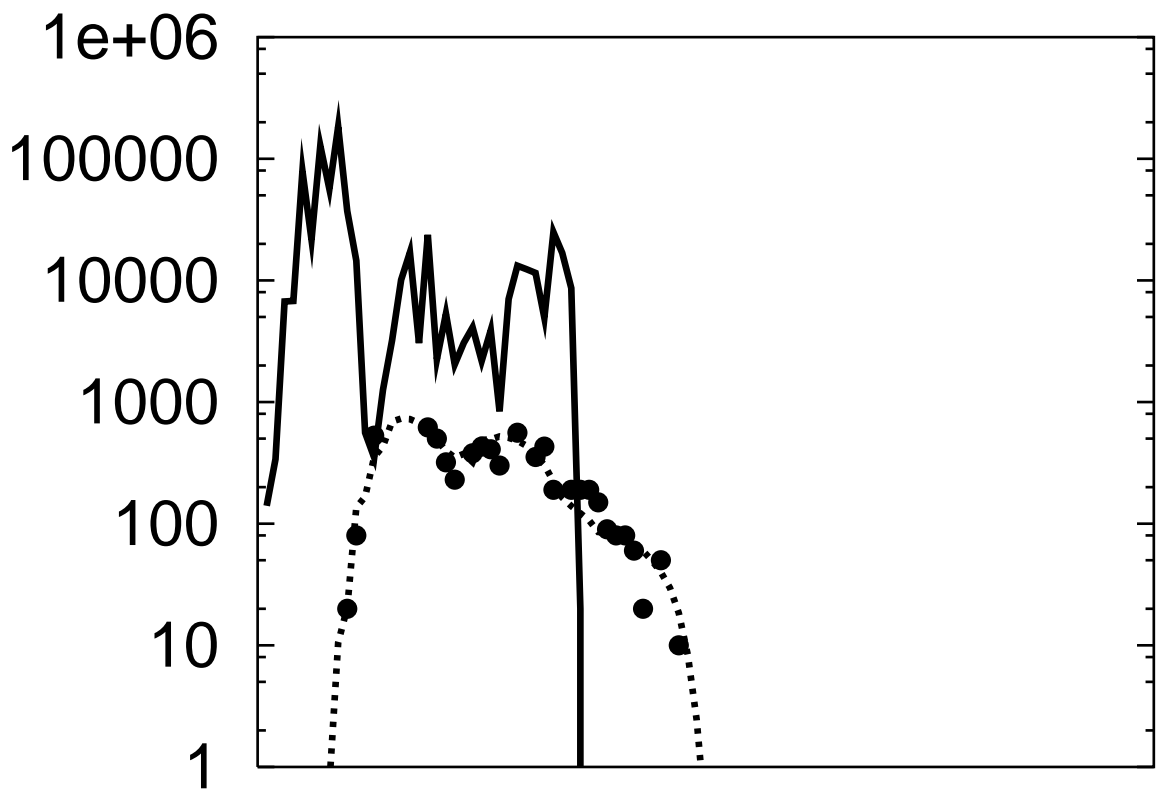
asex. parasites —
observ. gameto. •
expect gameto. ·····

parasites per μl blood



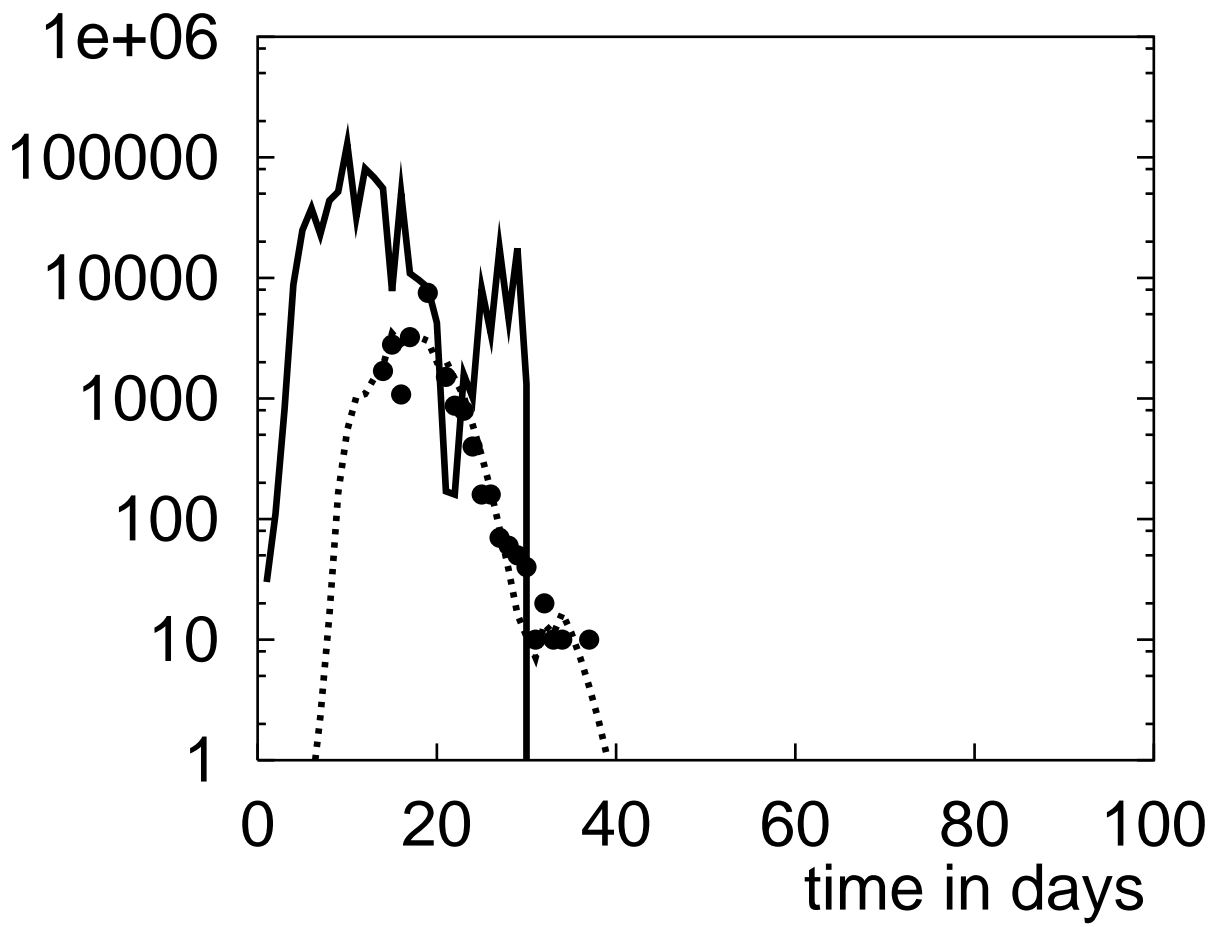
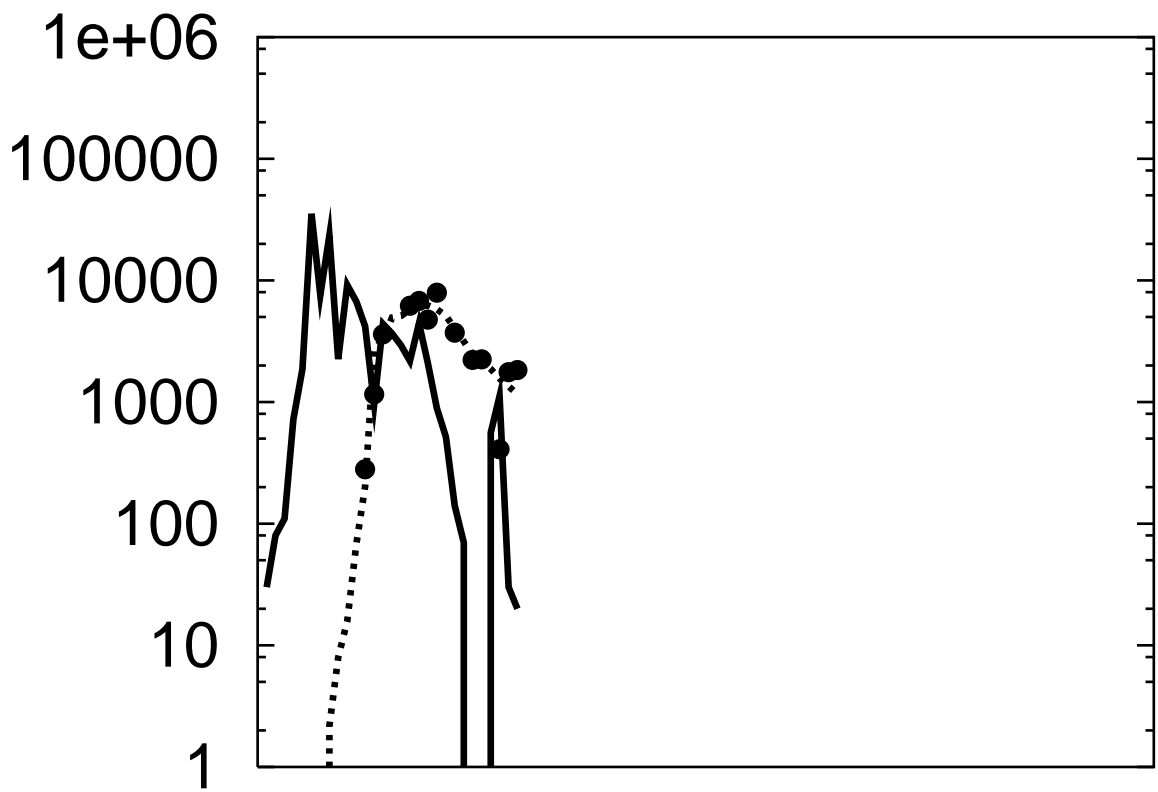
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



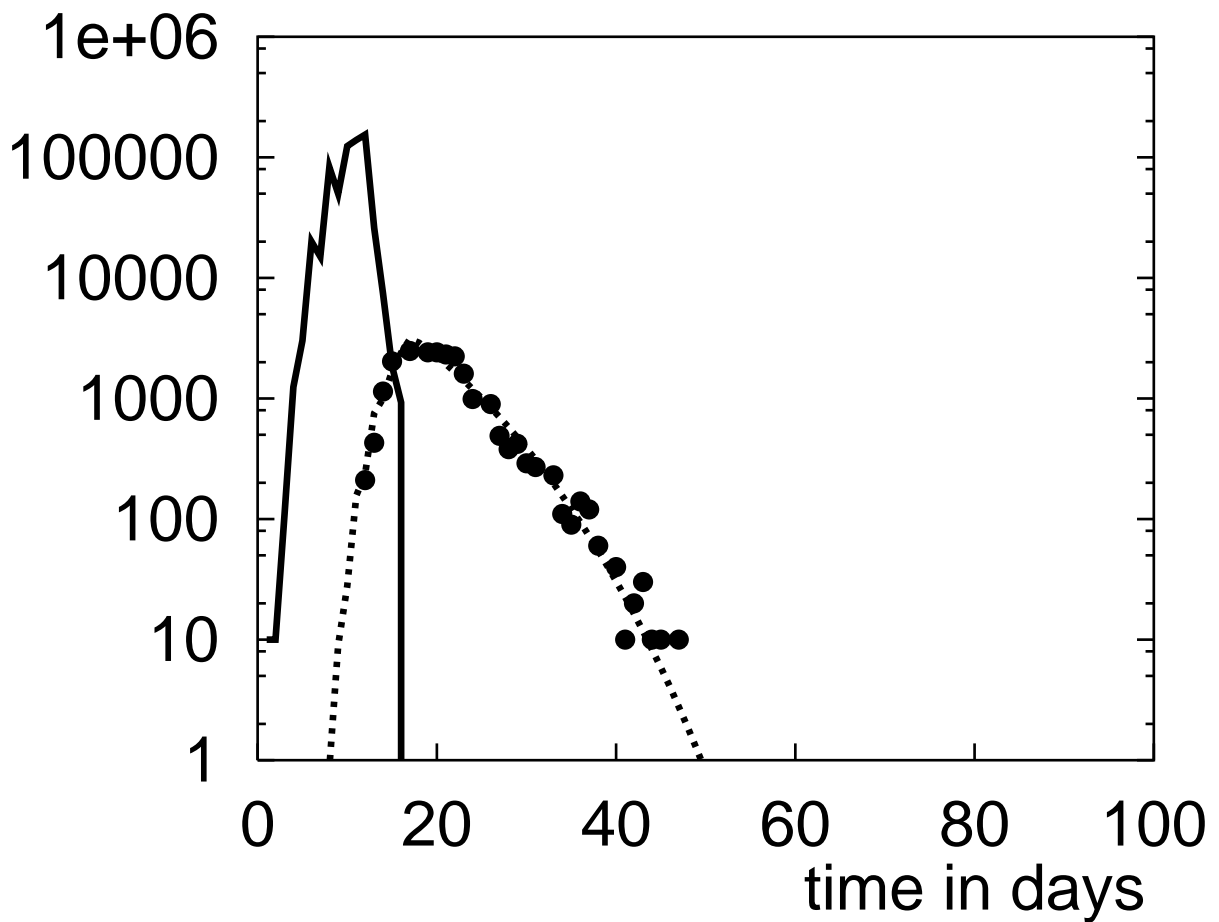
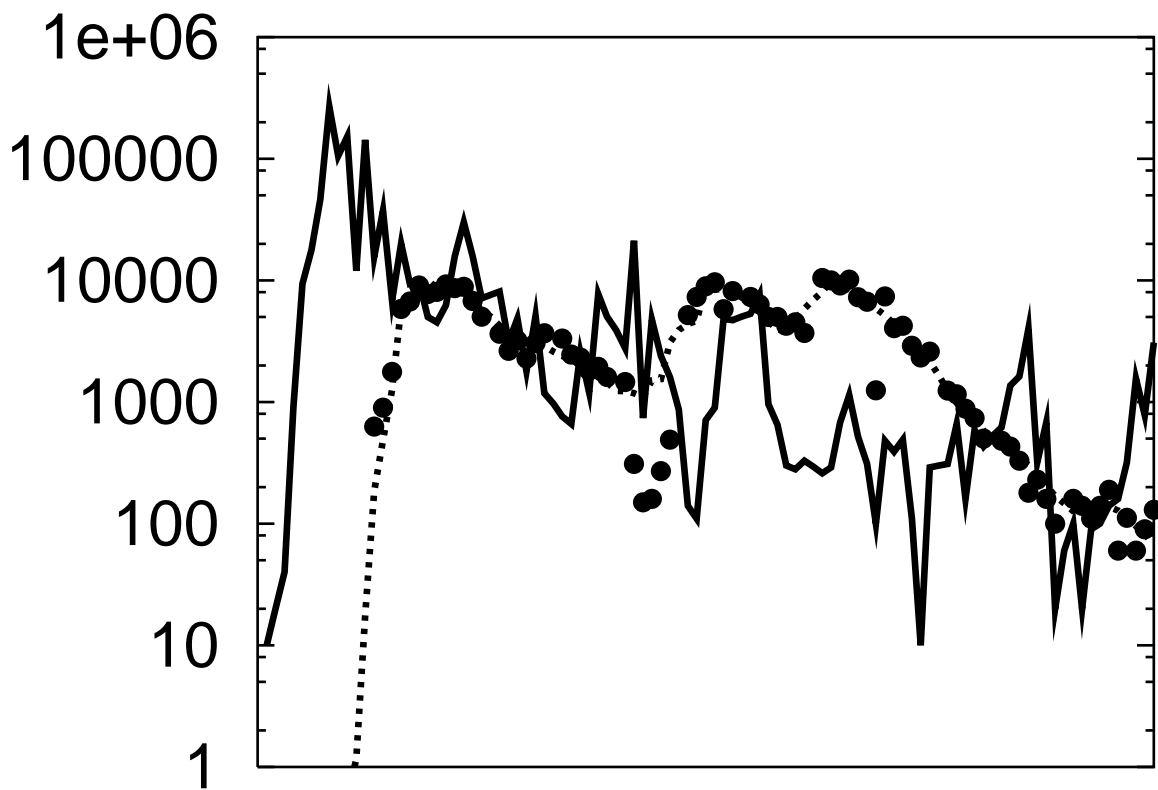
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observ. gameto. •
expect gameto. ·····

parasites per μl blood



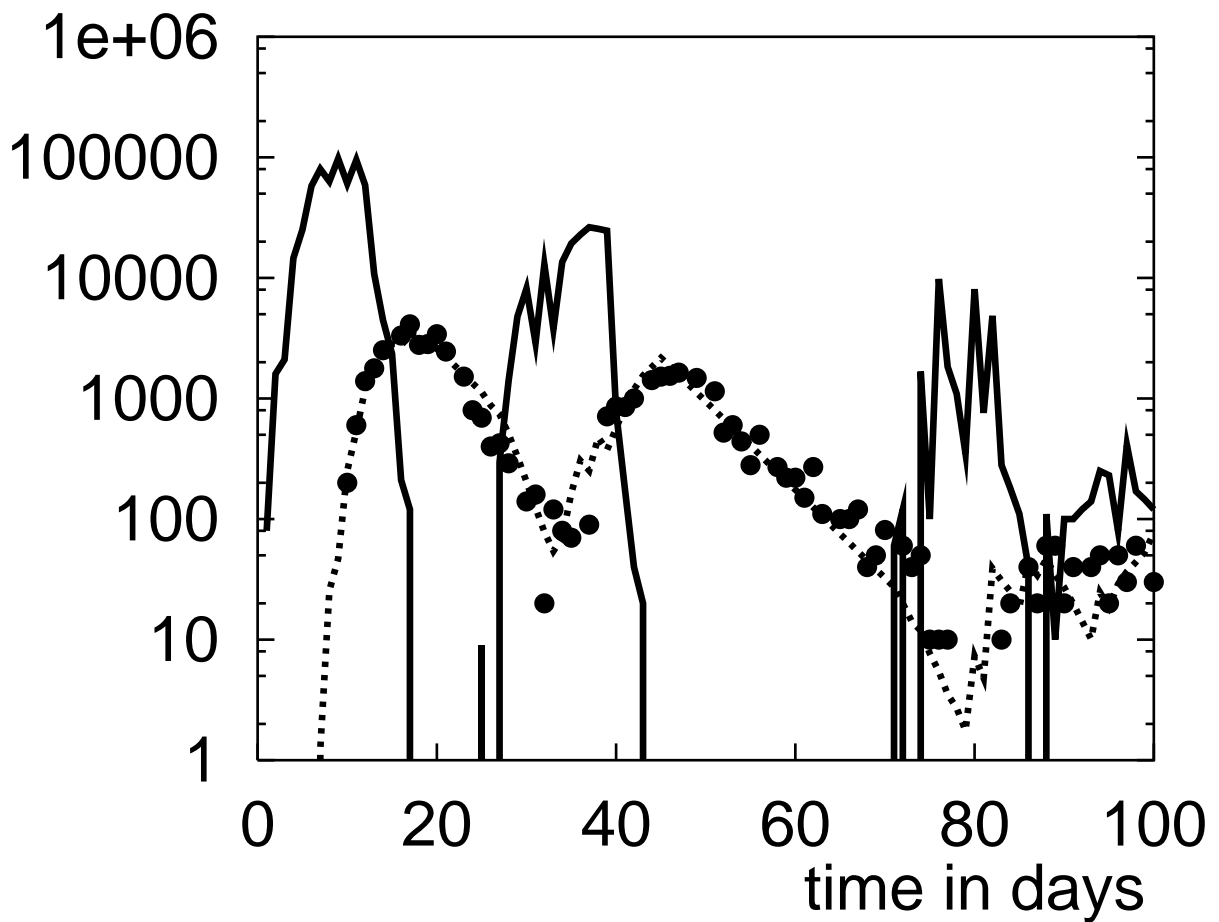
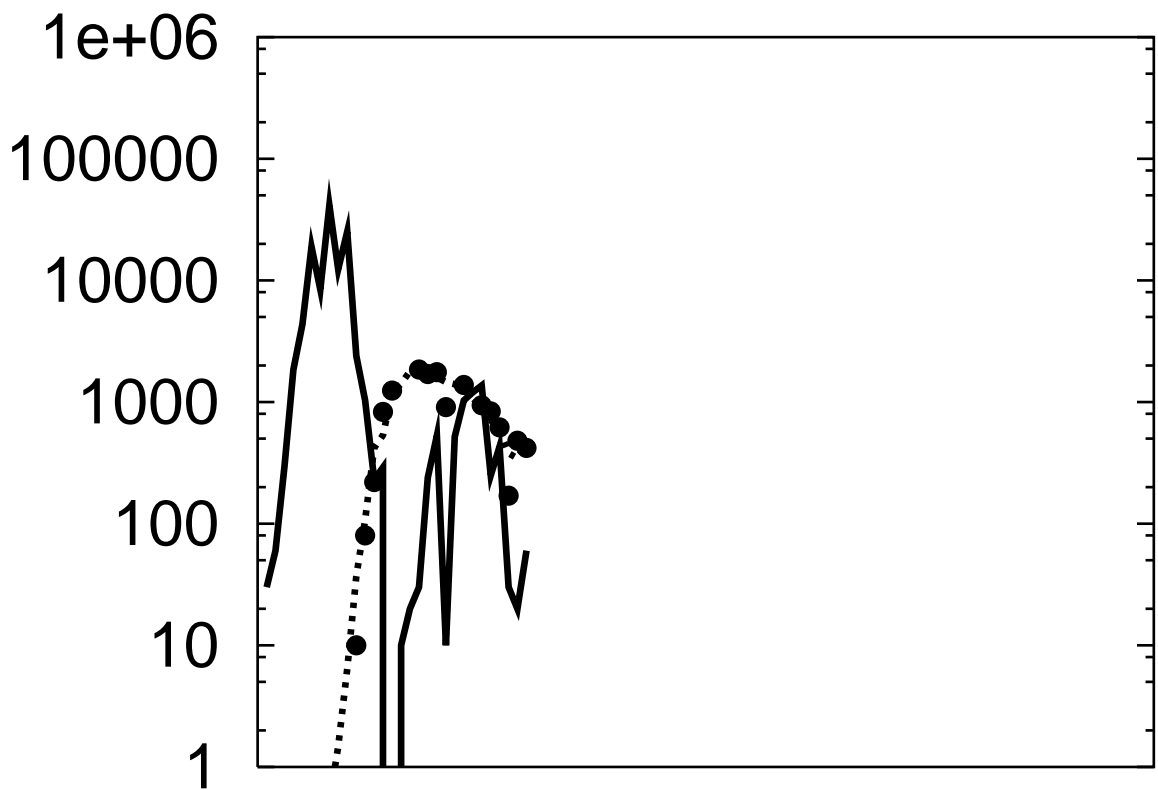
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observ. gameto. •
expect gameto. ·····

parasites per μl blood



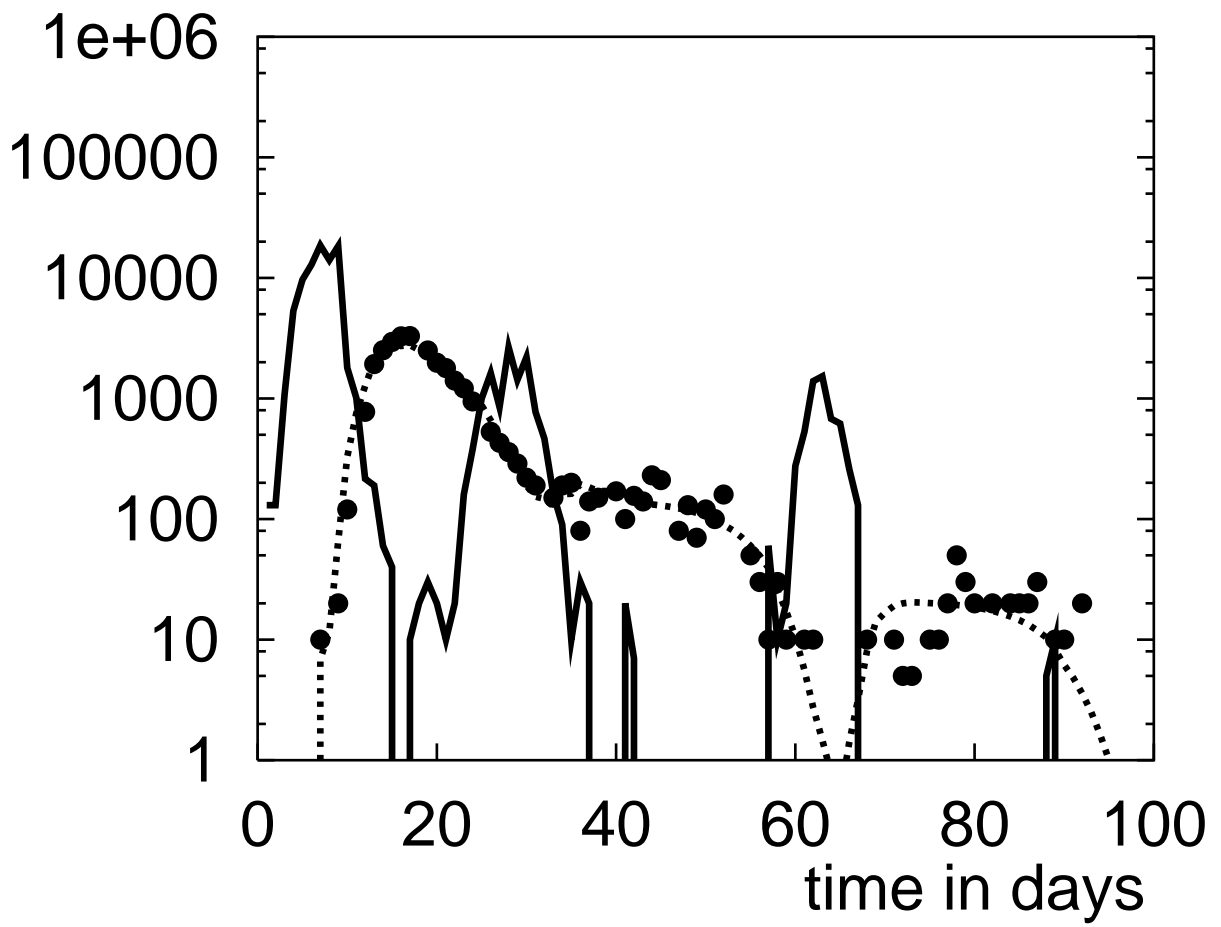
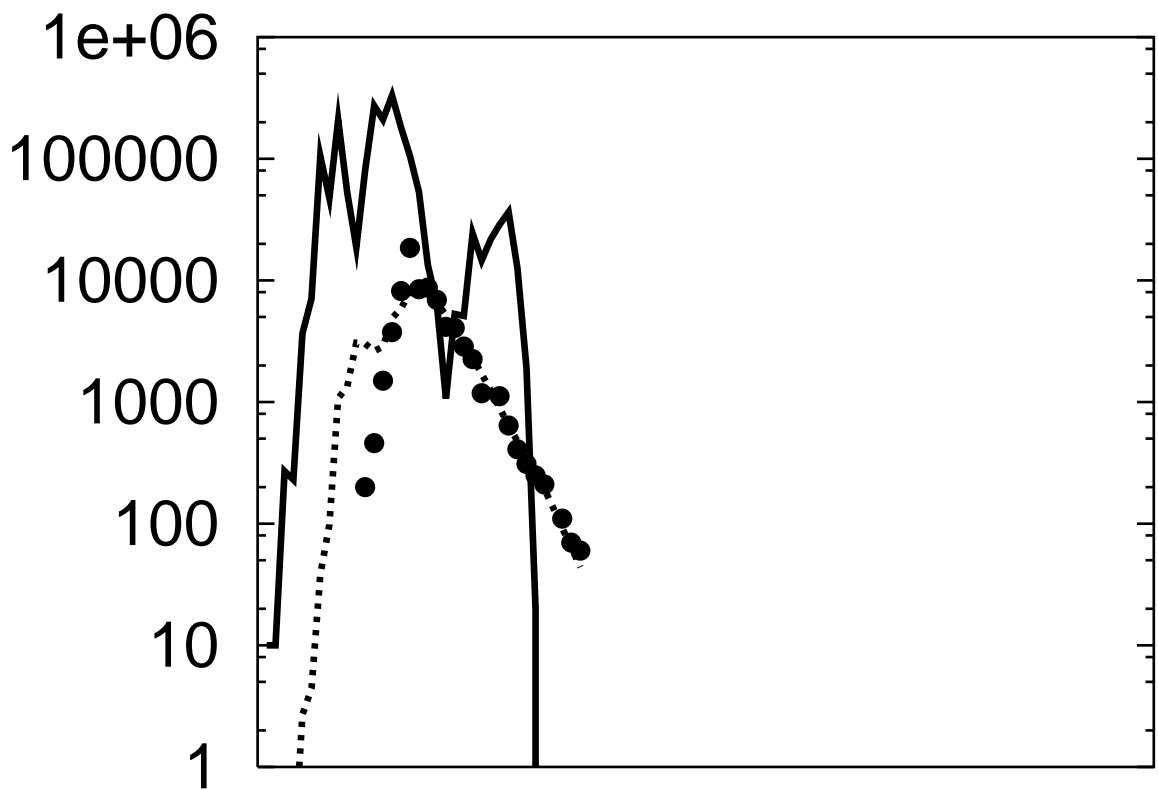
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



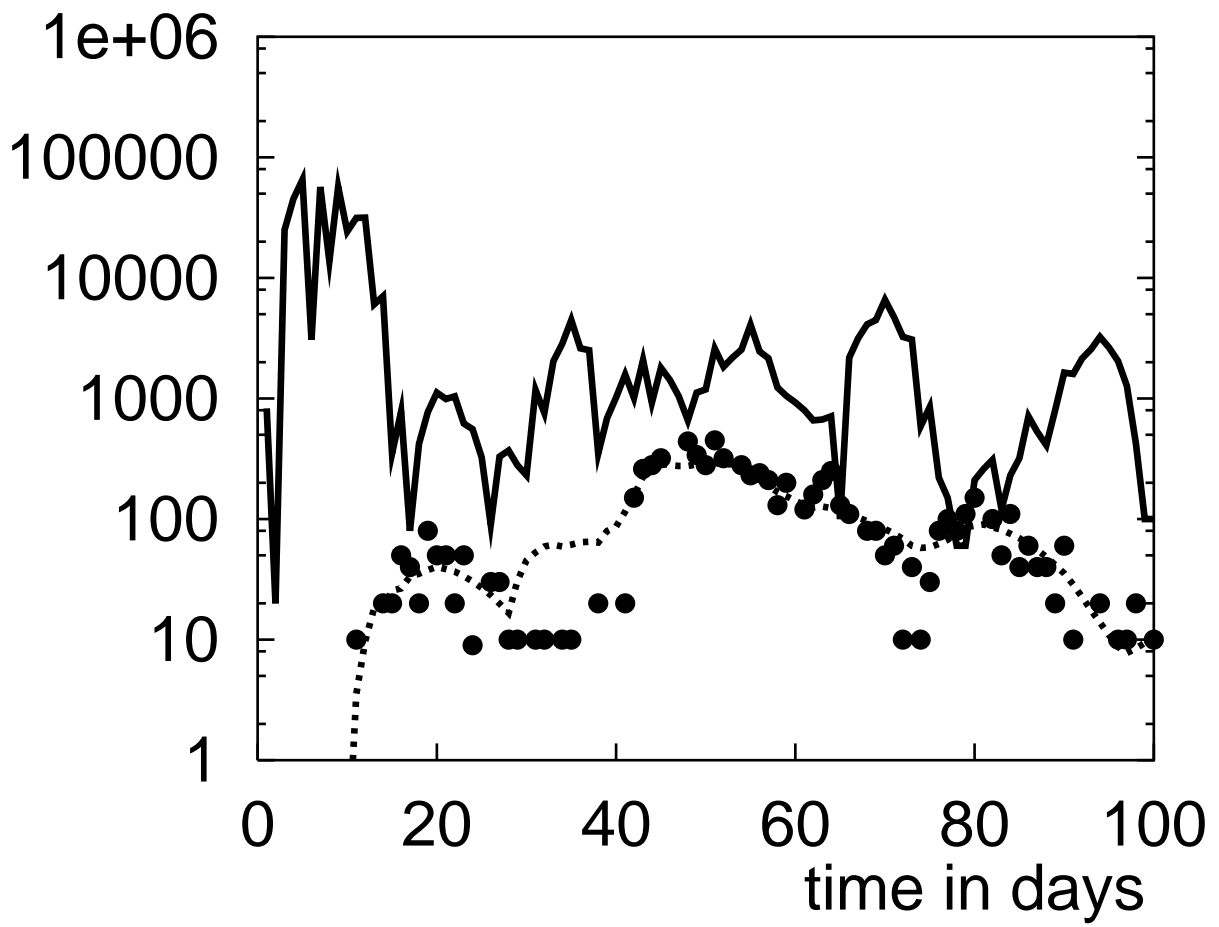
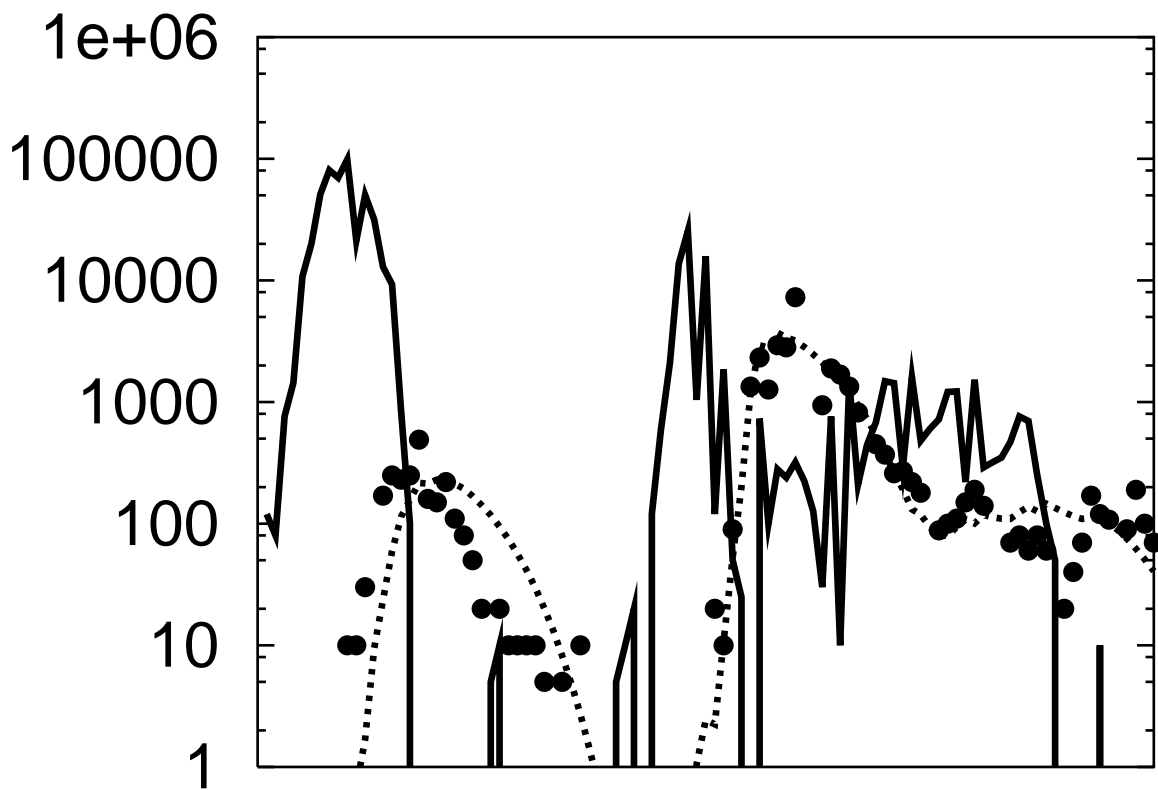
asex. parasites —
observ. gameto. •
expect gameto. ···

parasites per μl blood



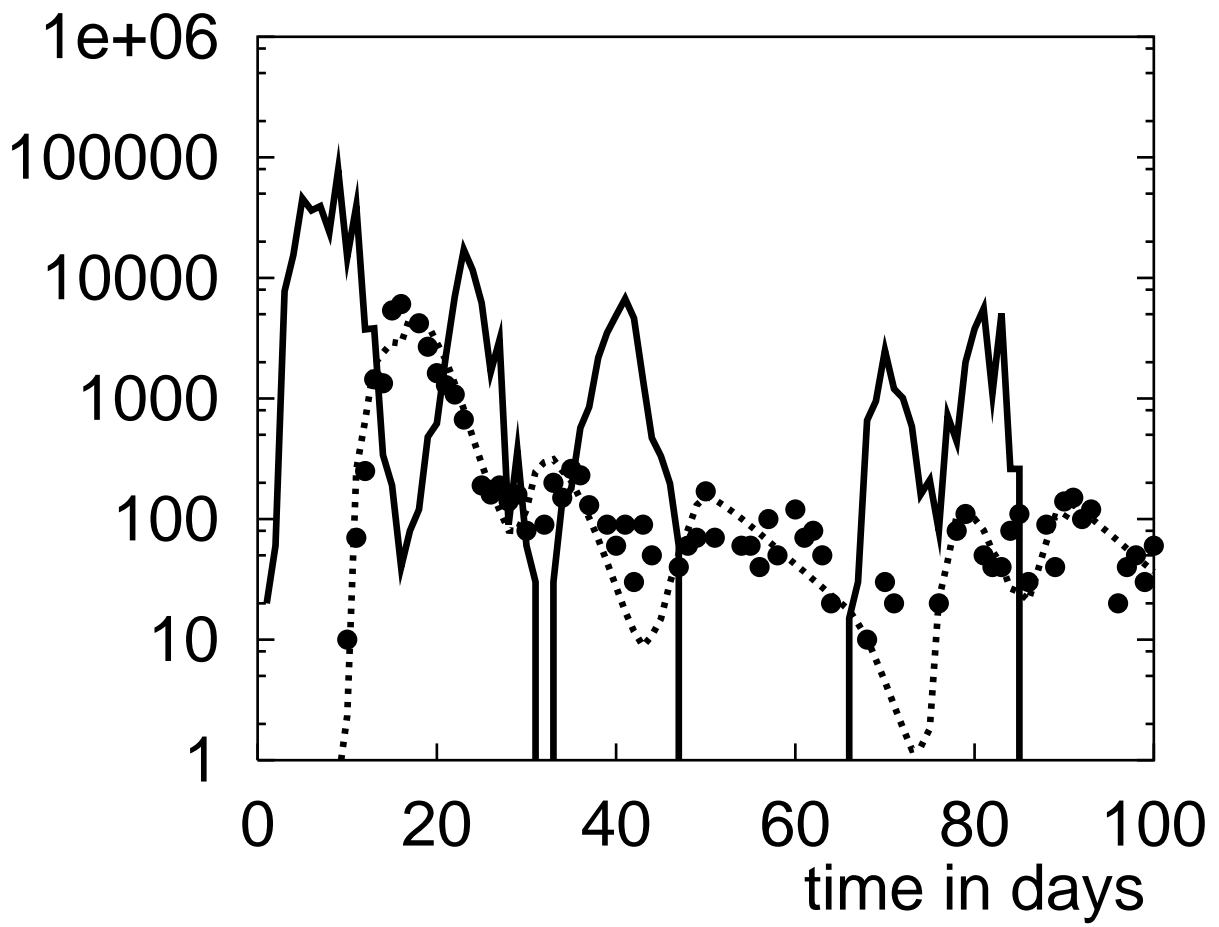
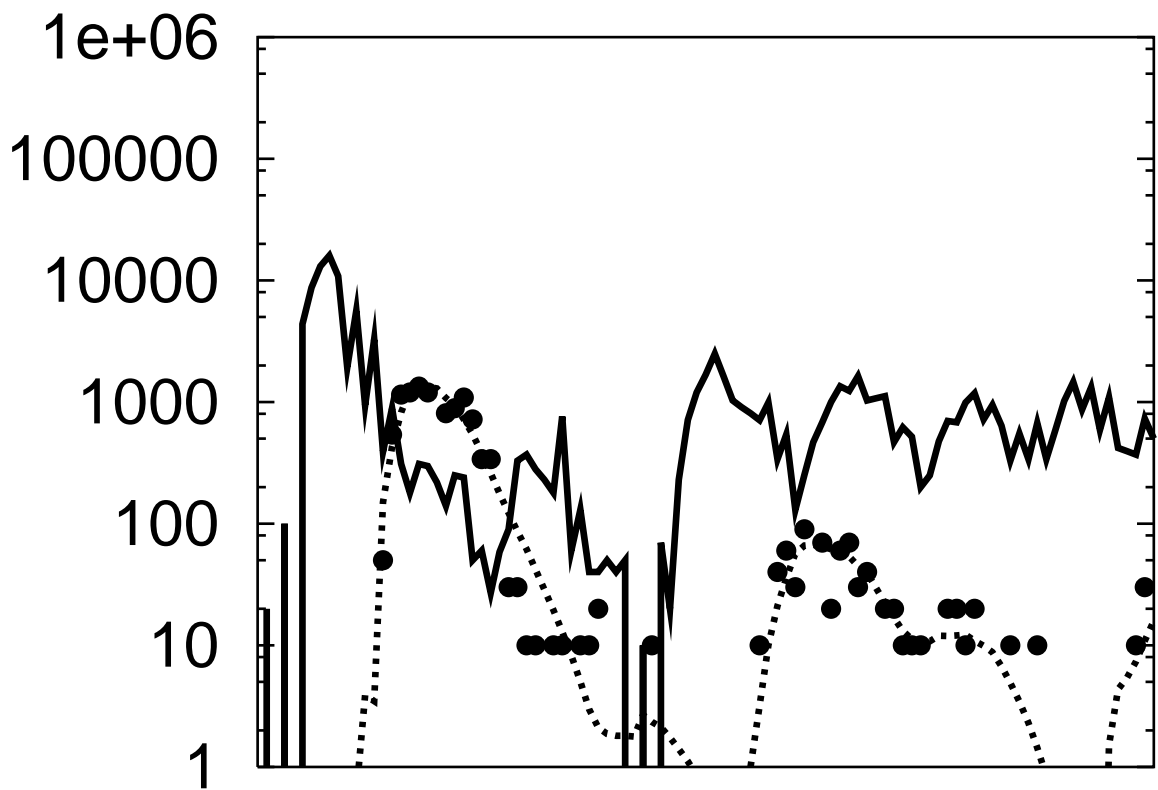
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observ. gameto. •
expect gameto. ·····

parasites per μl blood



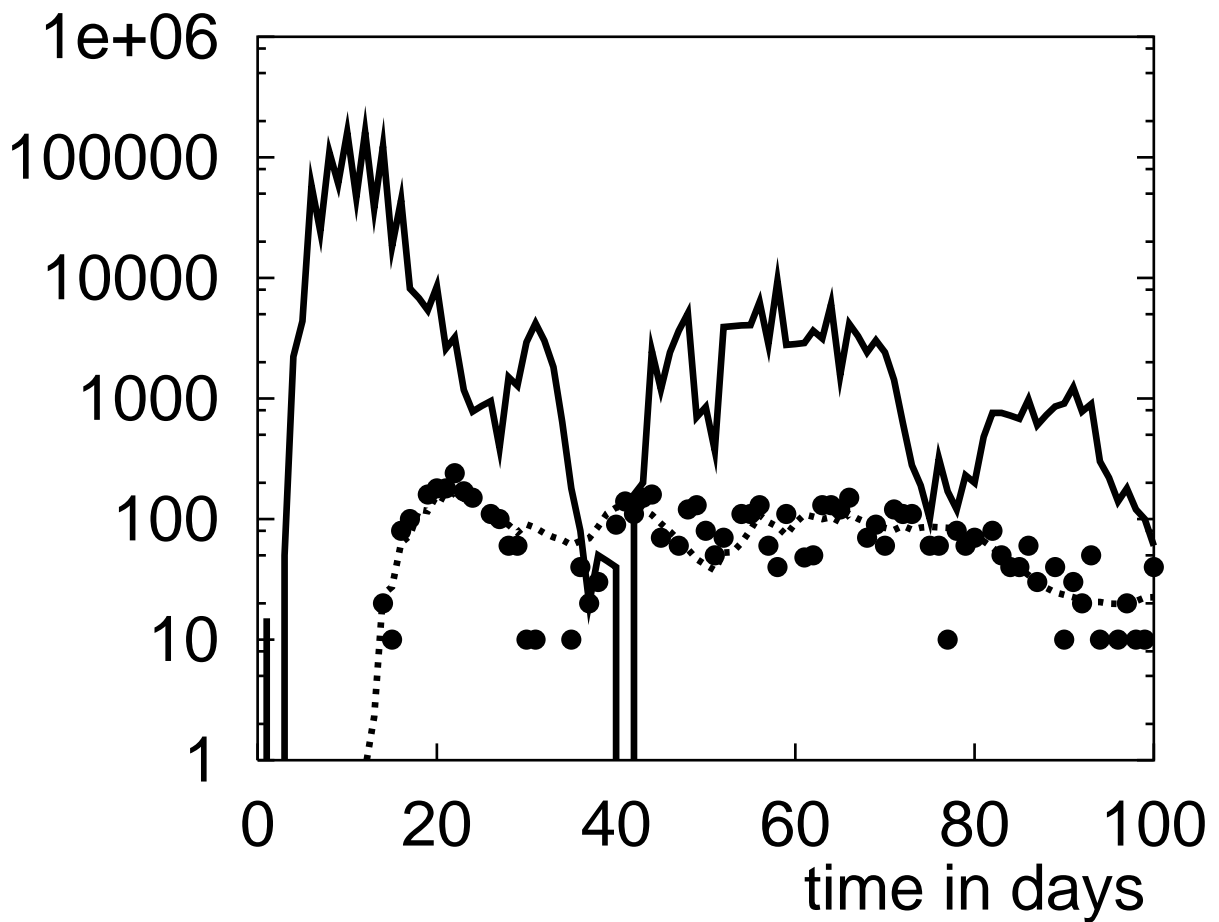
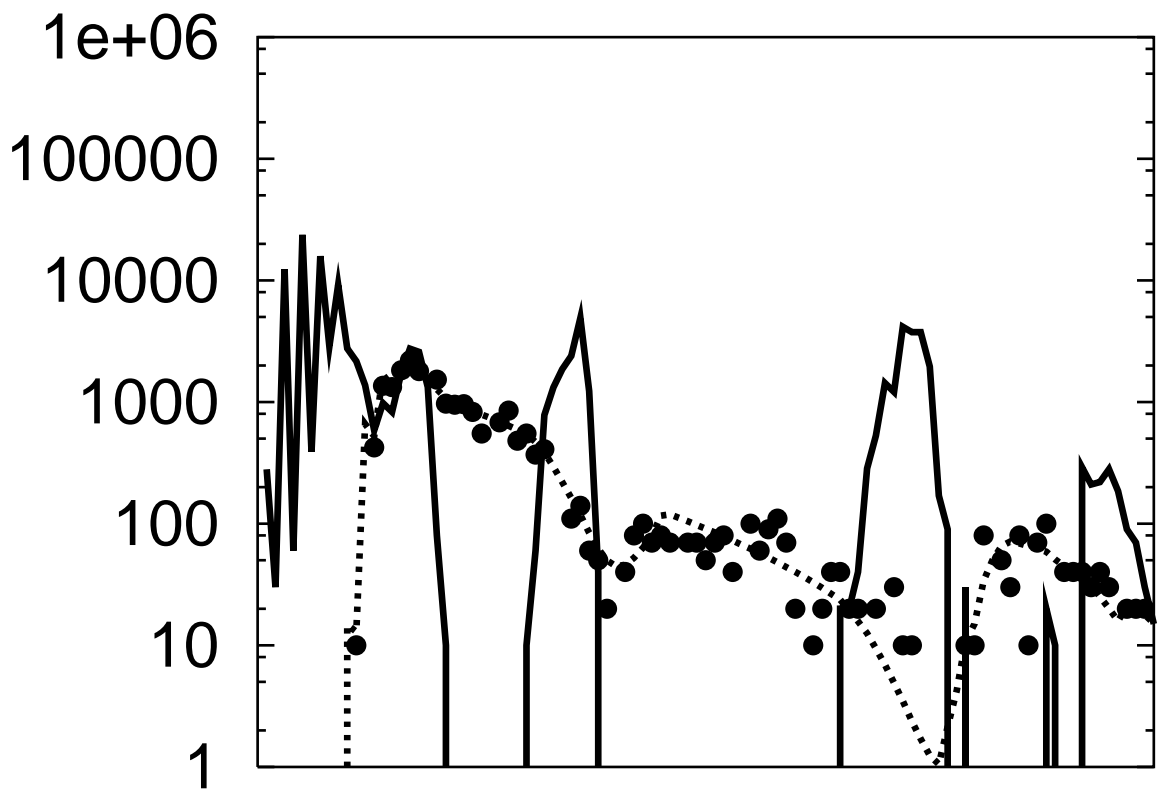
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



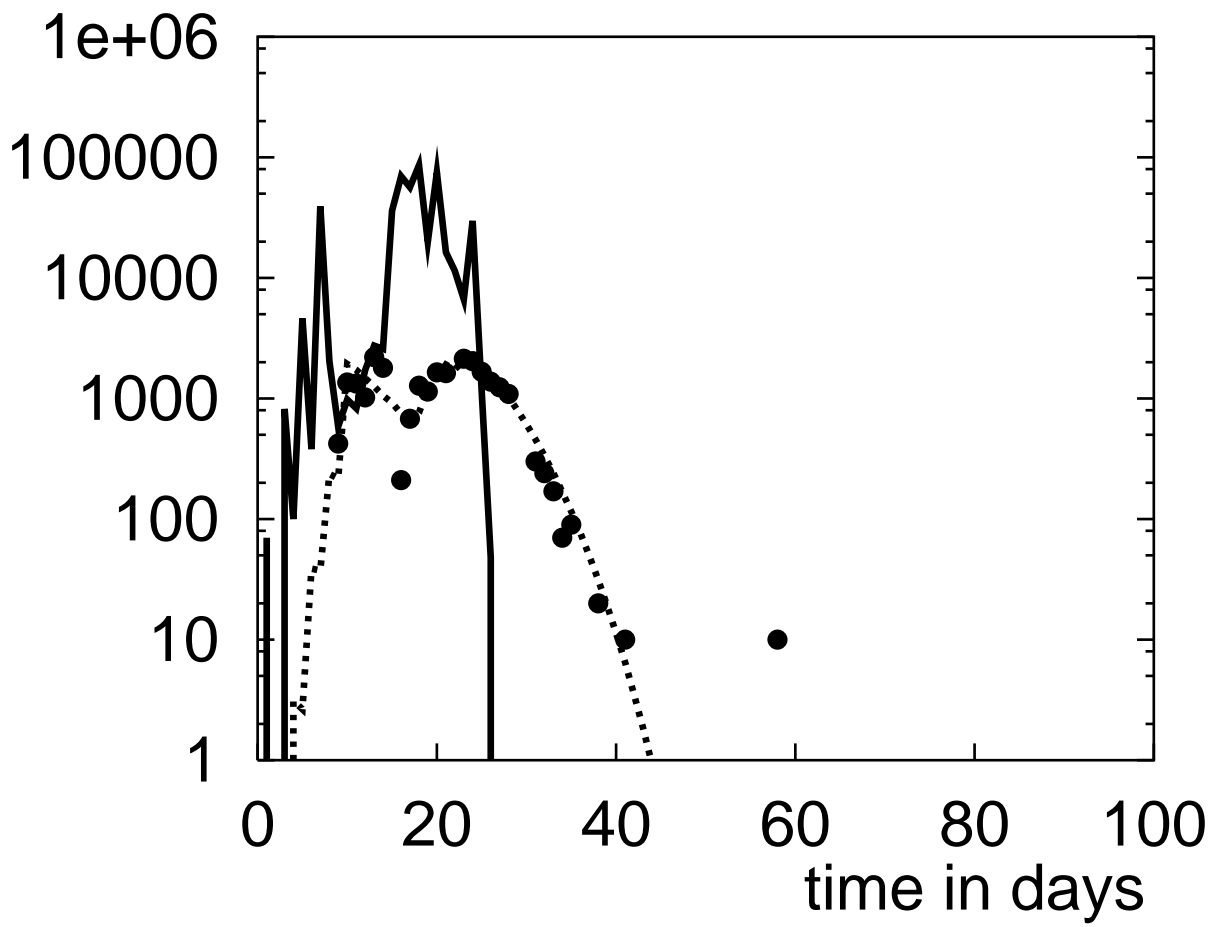
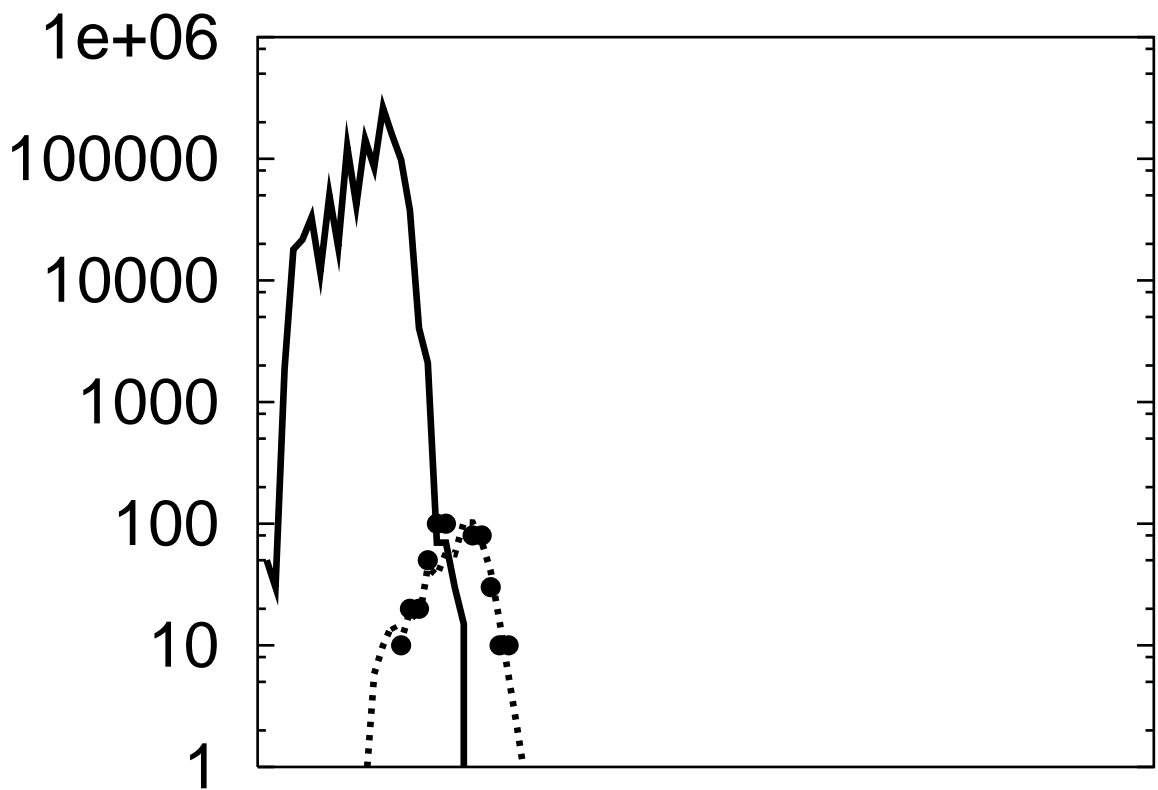
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observ. gameto. •
expect gameto. ·····

parasites per μl blood



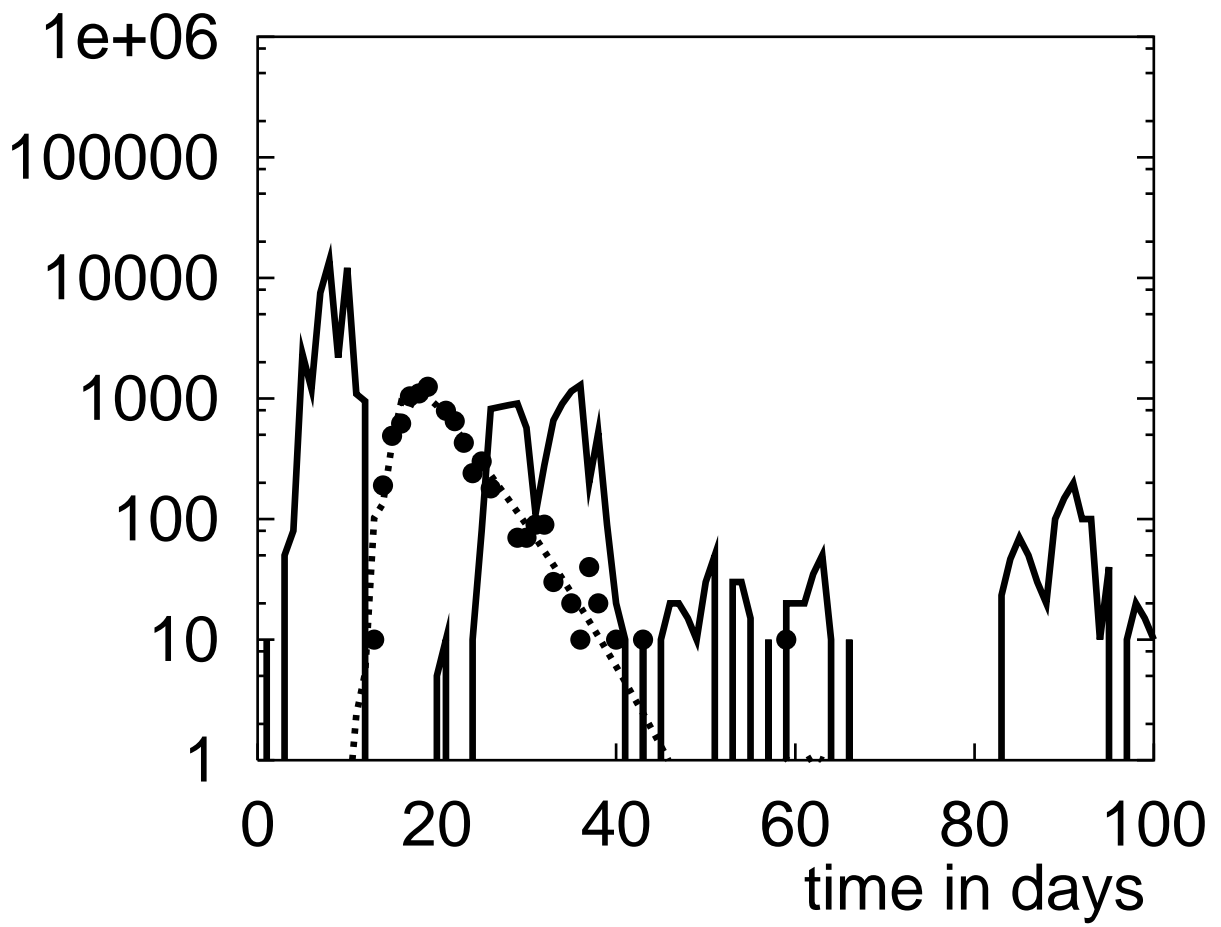
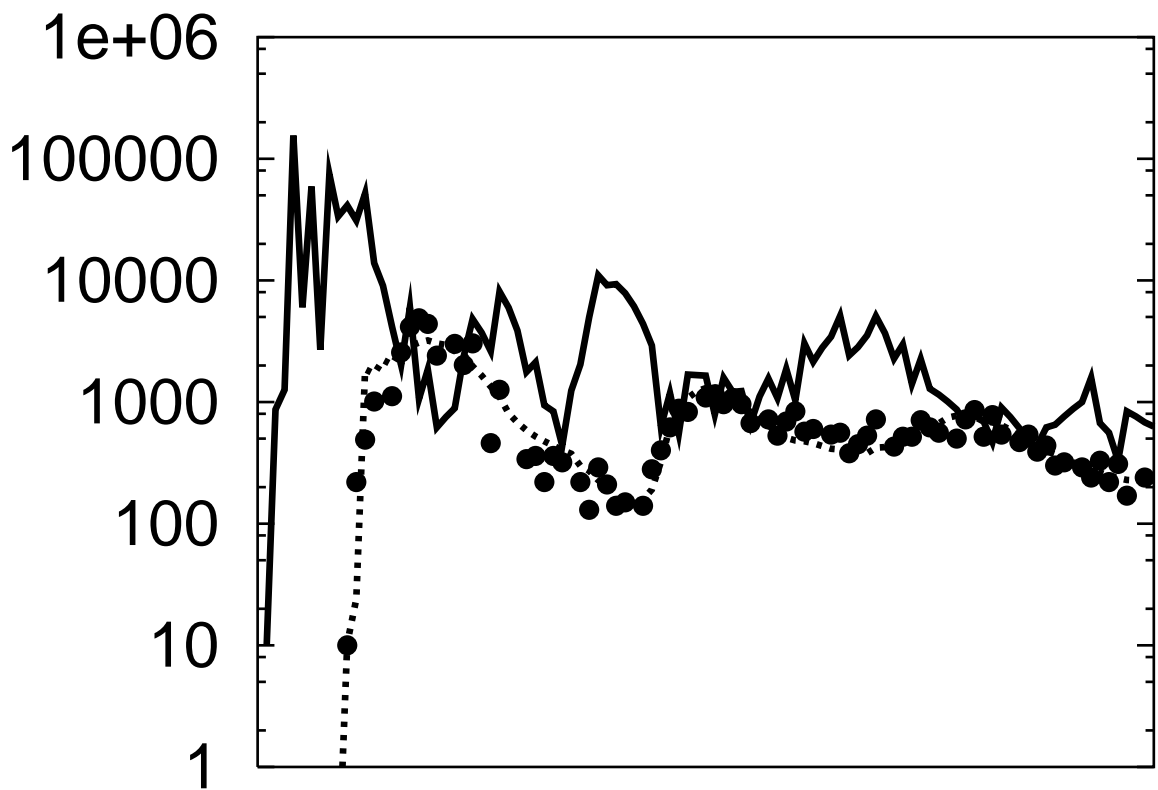
asex. parasites —
observ. gameto. •
expect gameto. ·····

parasites per μl blood



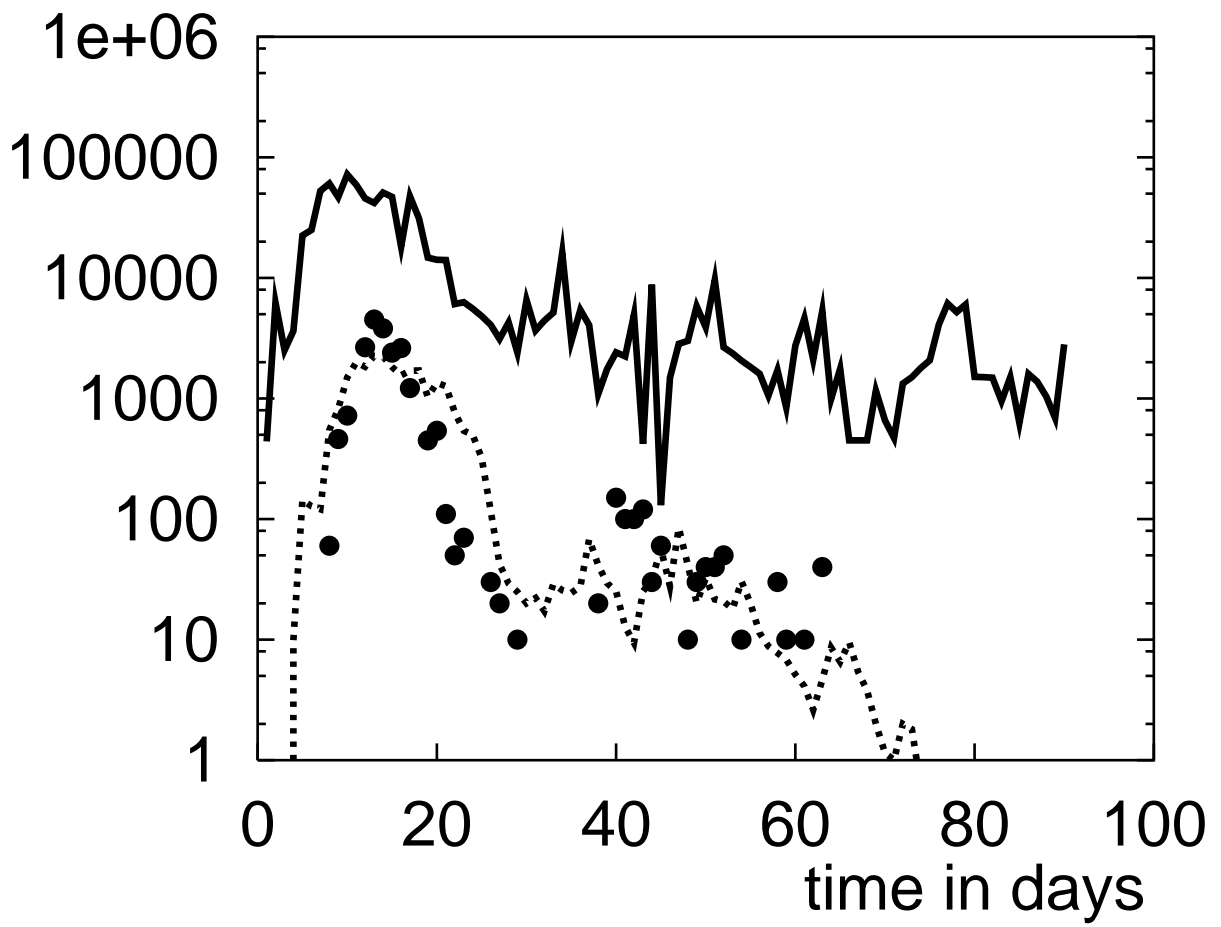
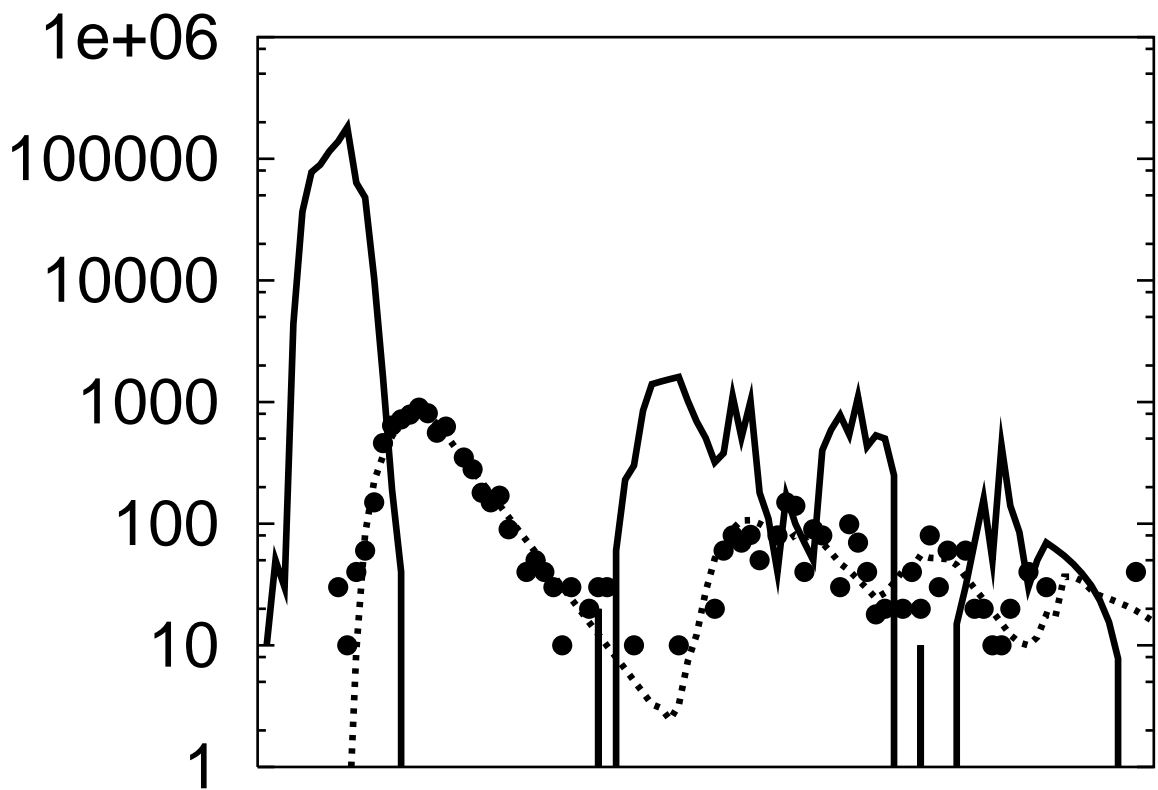
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observ. gameto. •
expect gameto. ·····

parasites per μl blood



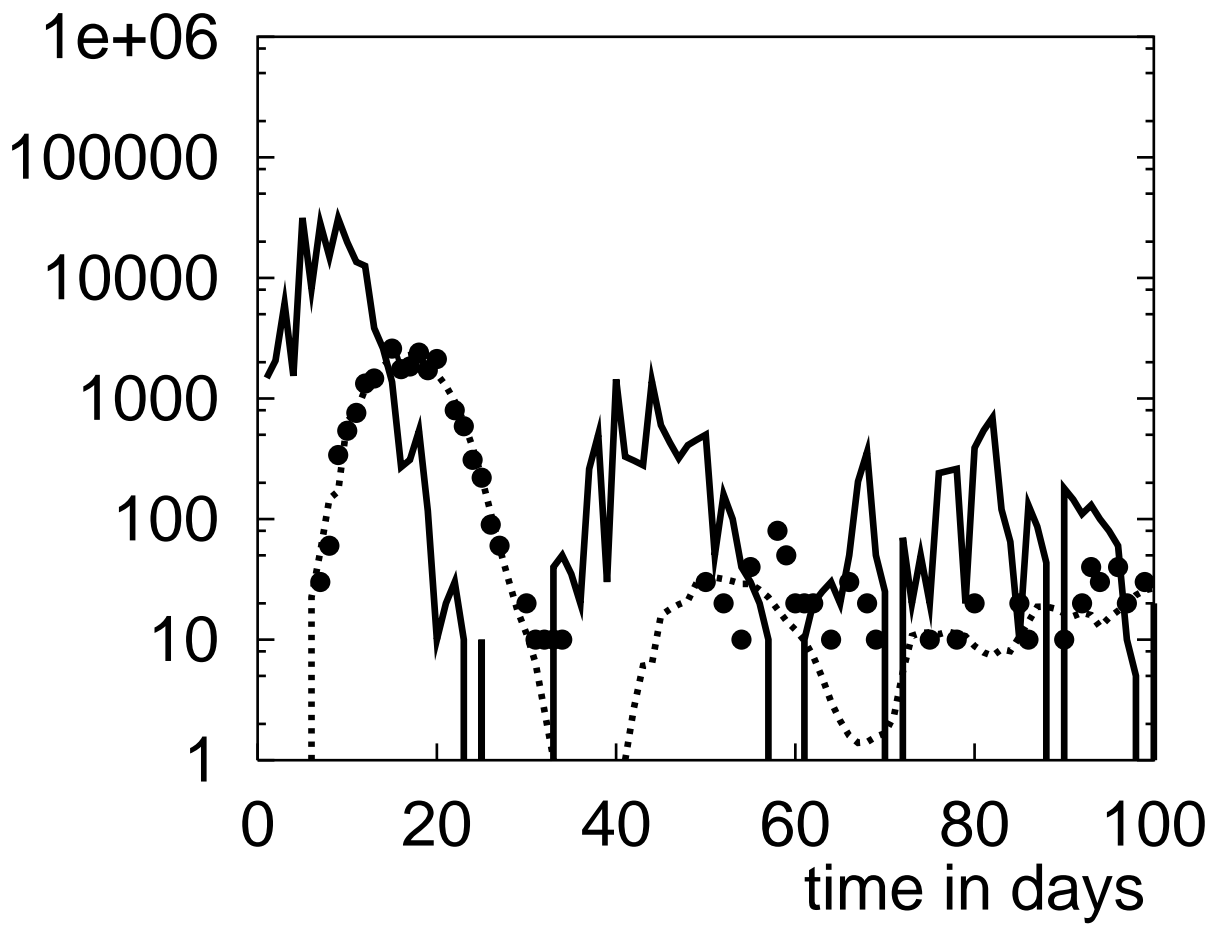
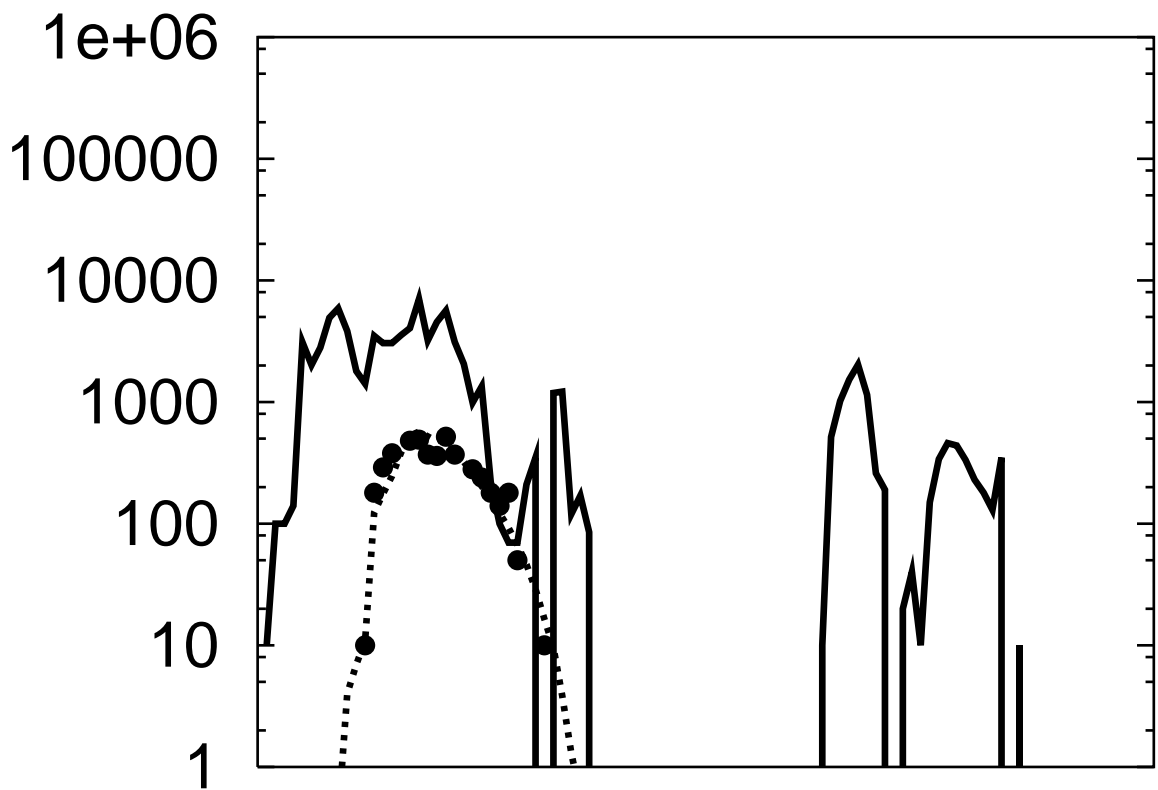
asex. parasites —
observ. gameto. •
expect gameto. ·····

parasites per μl blood



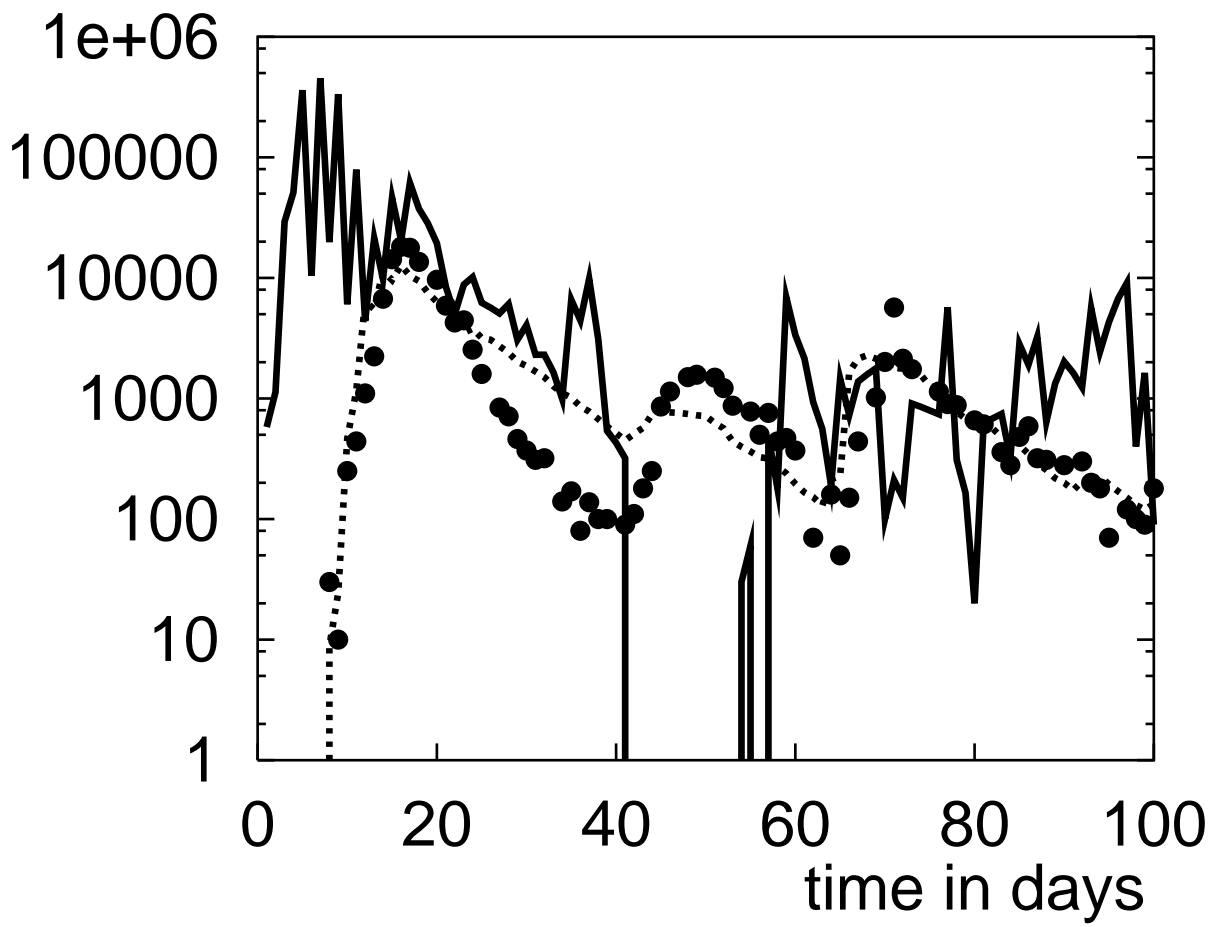
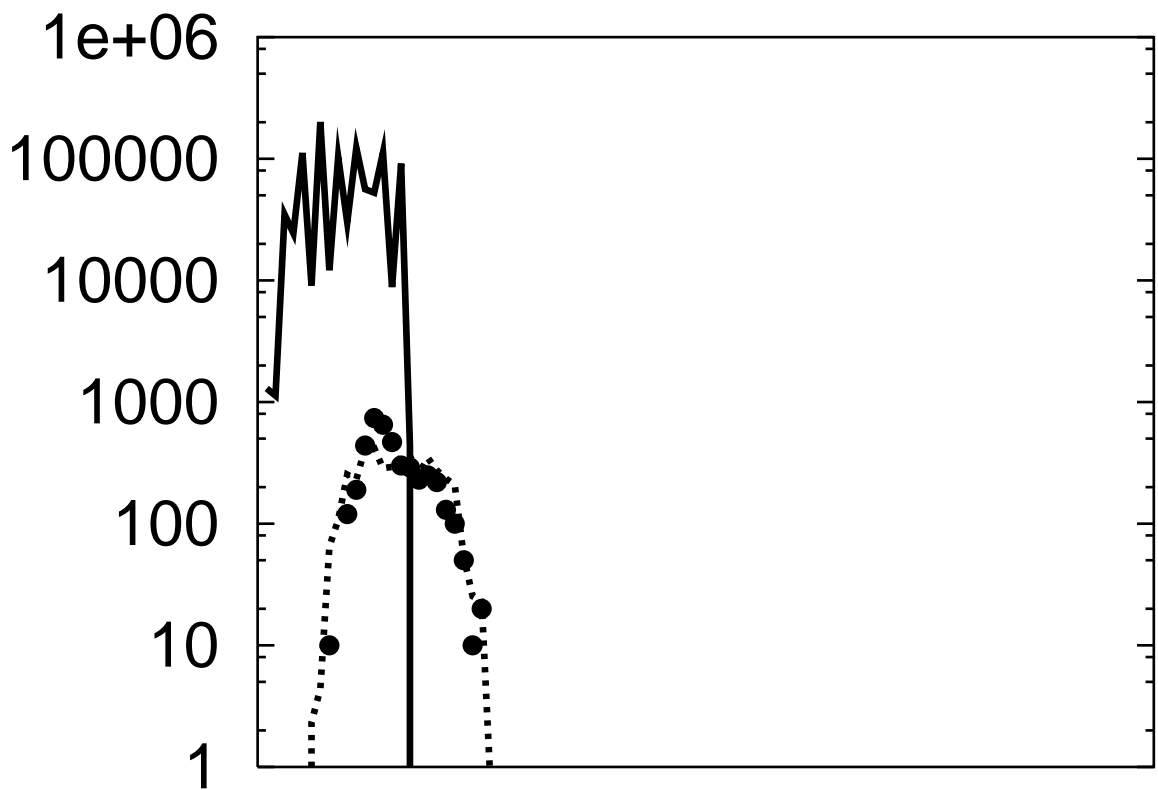
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observ. gameto. •
expect gameto. ·····

parasites per μl blood



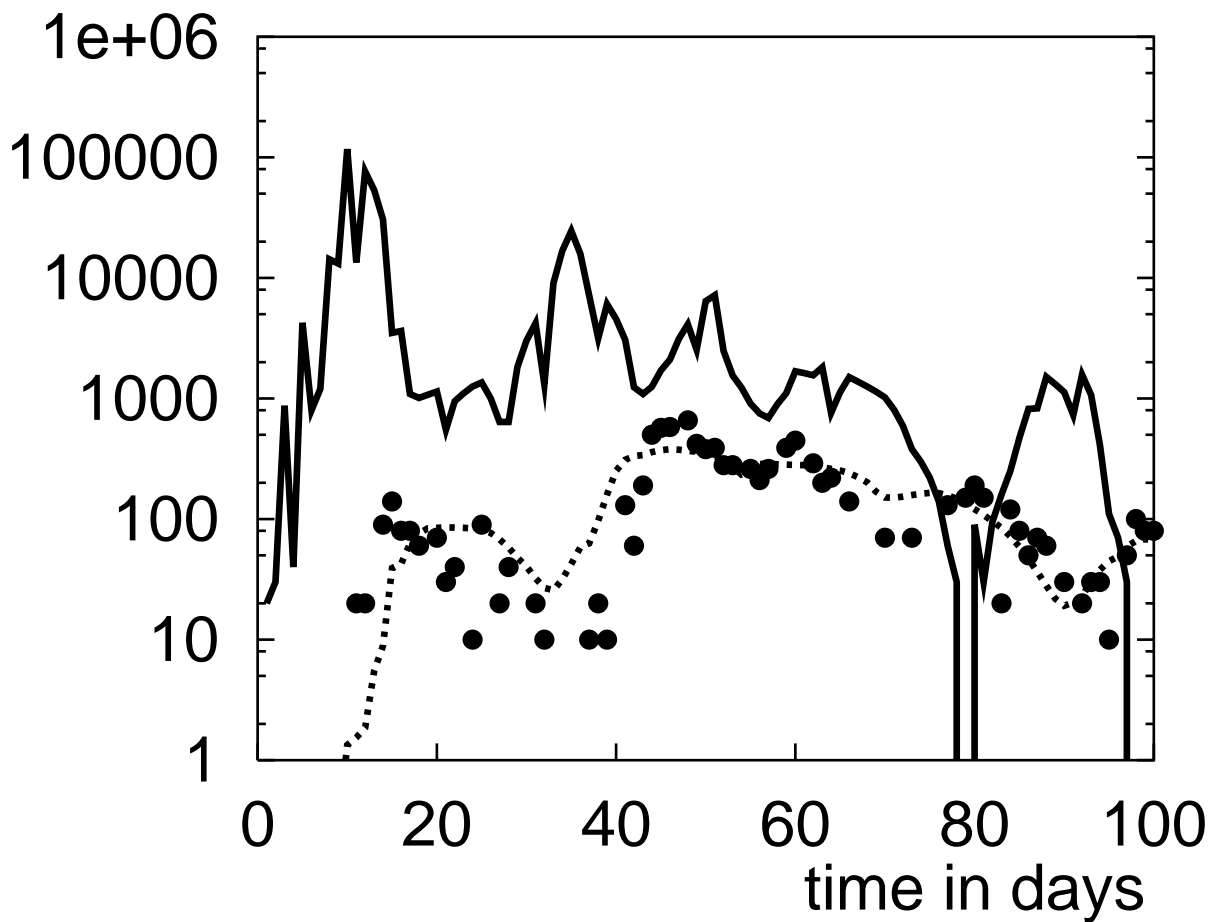
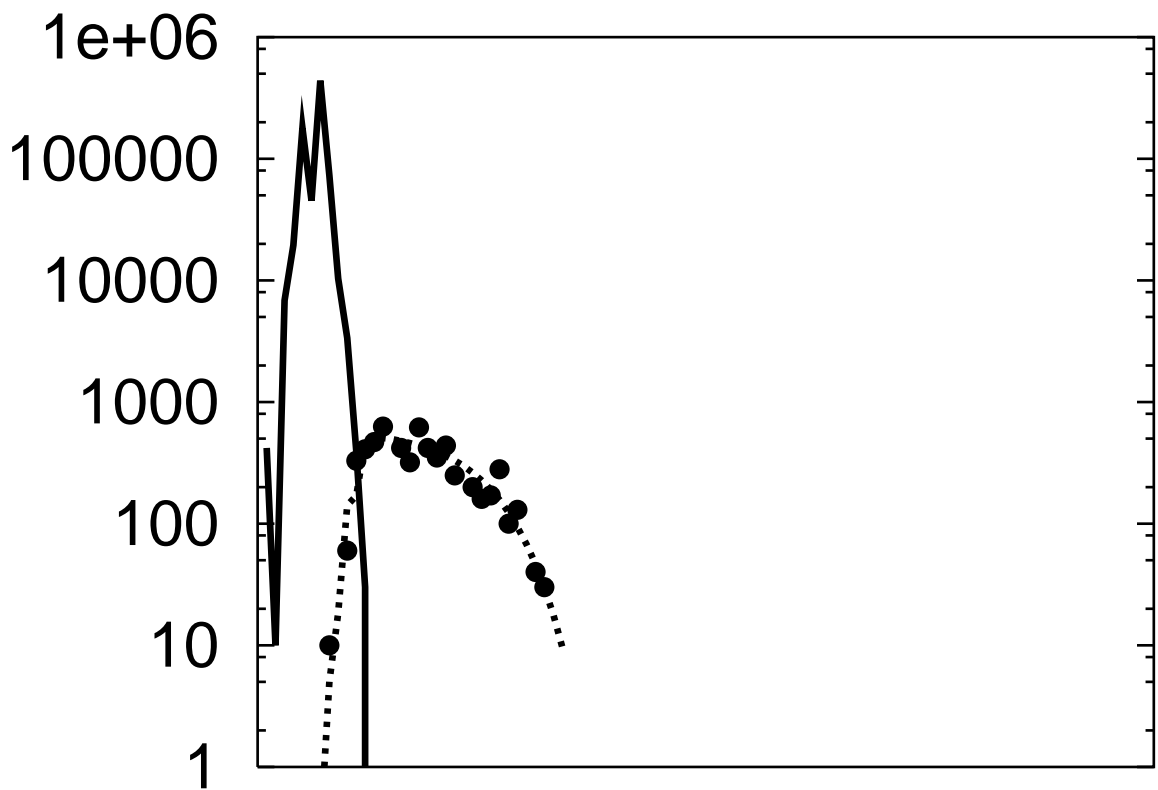
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observ. gameto. •
expect gameto. ·····

parasites per μl blood



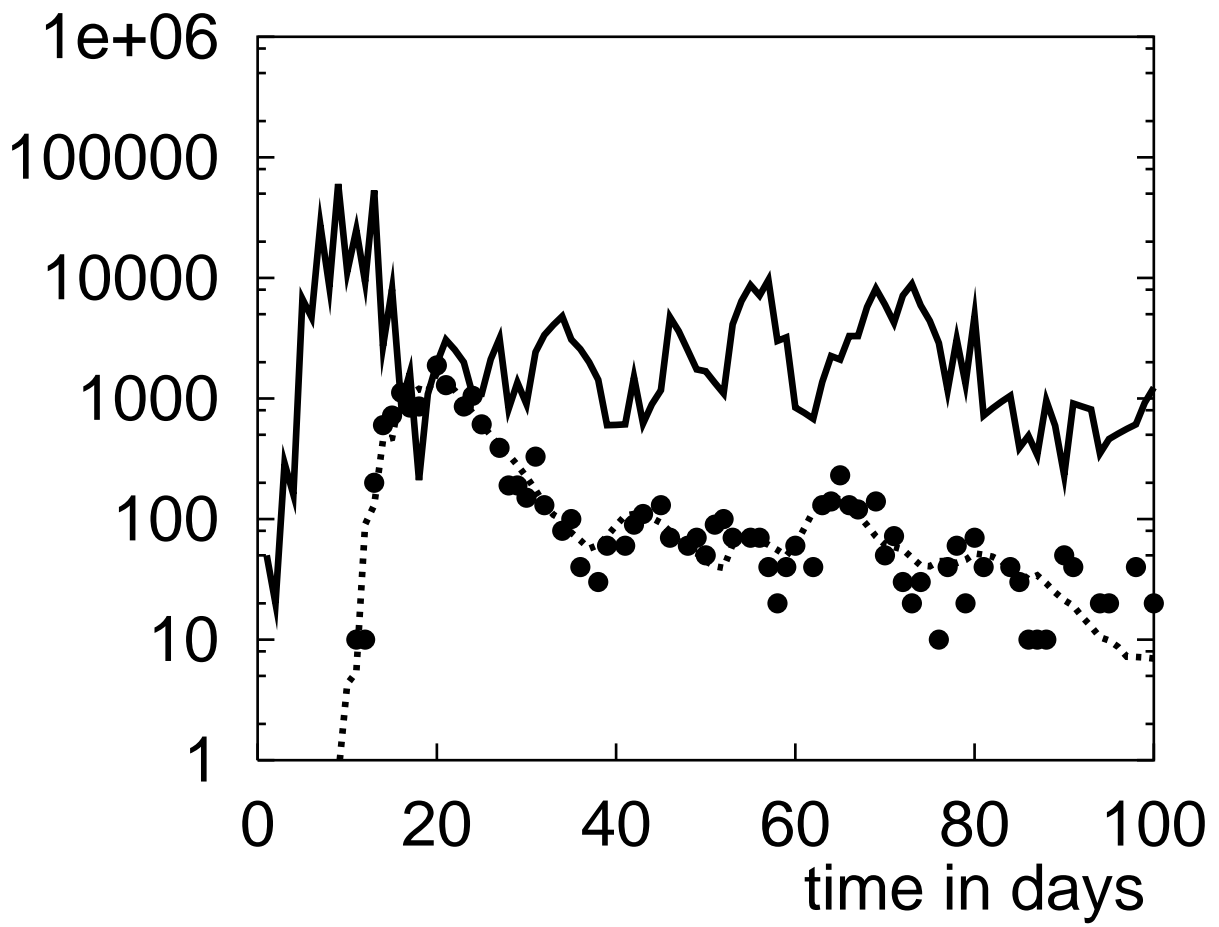
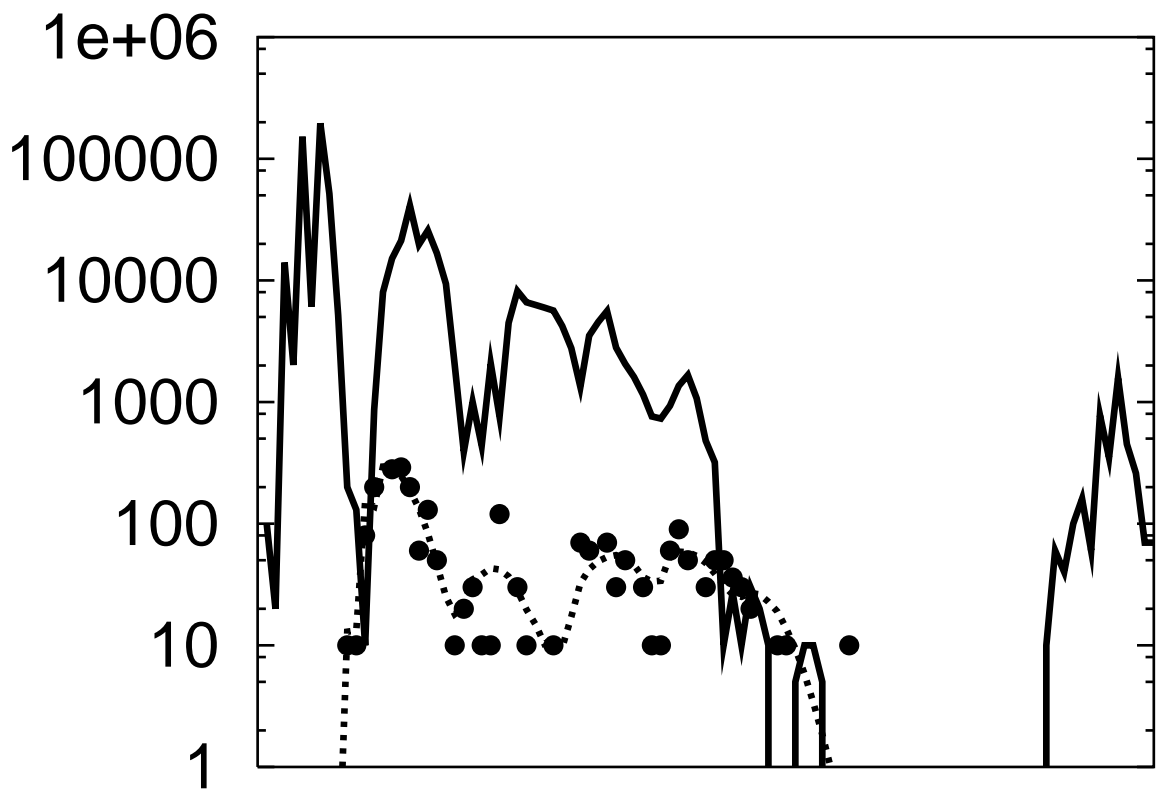
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observ. gameto. •
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parasites per μl blood



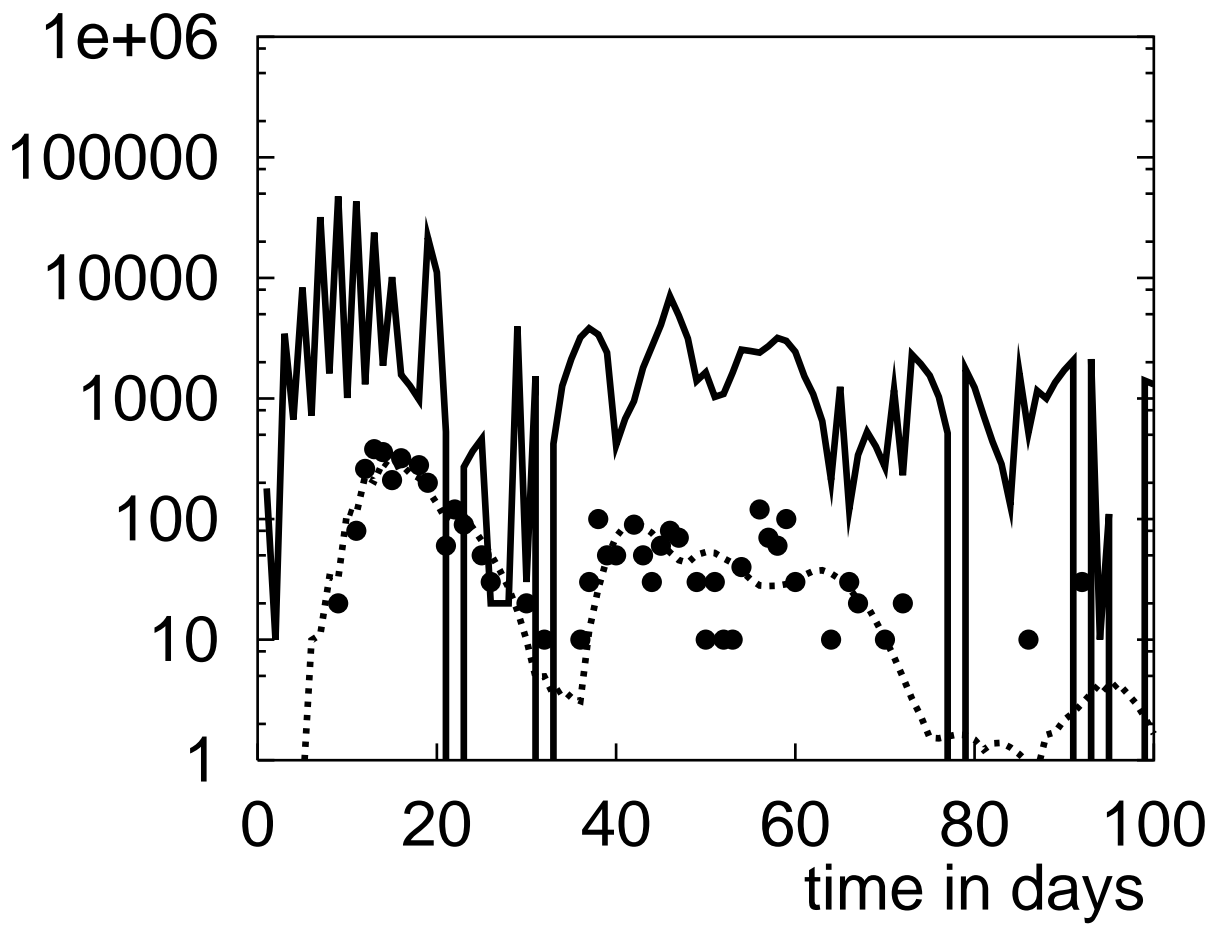
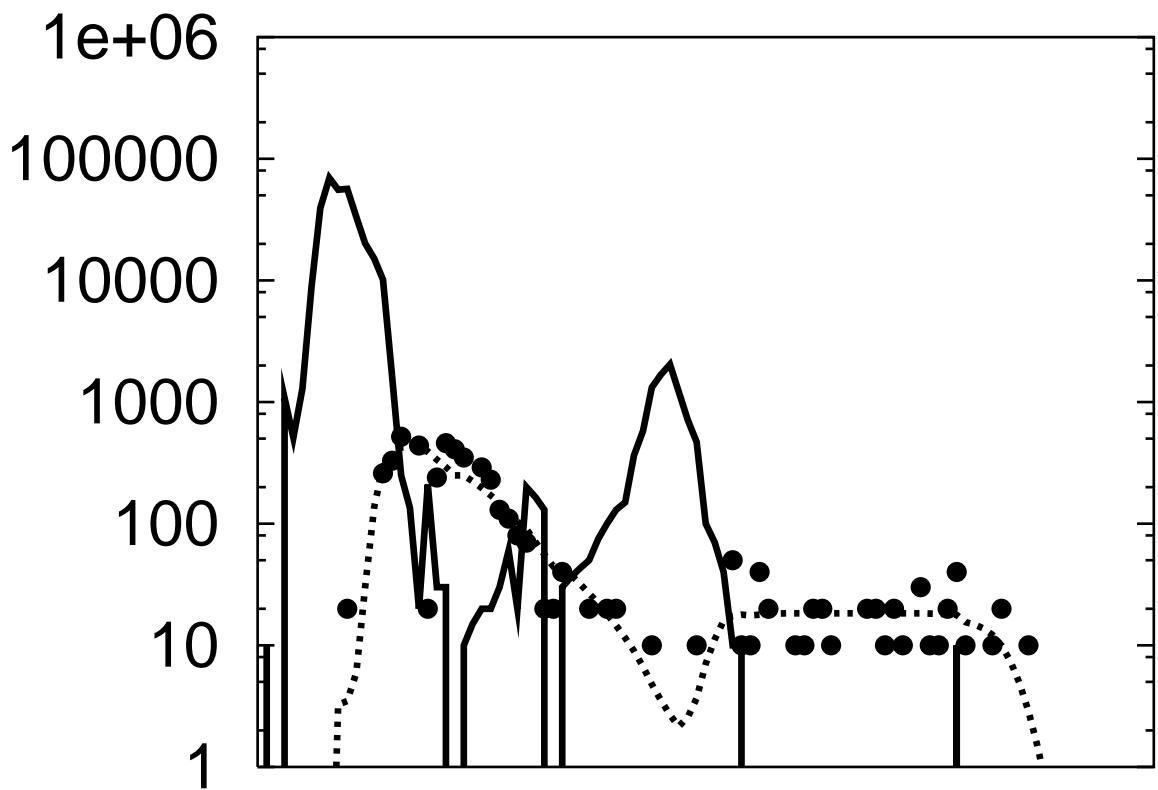
asex. parasites ———
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expect gameto. ·····

parasites per μl blood



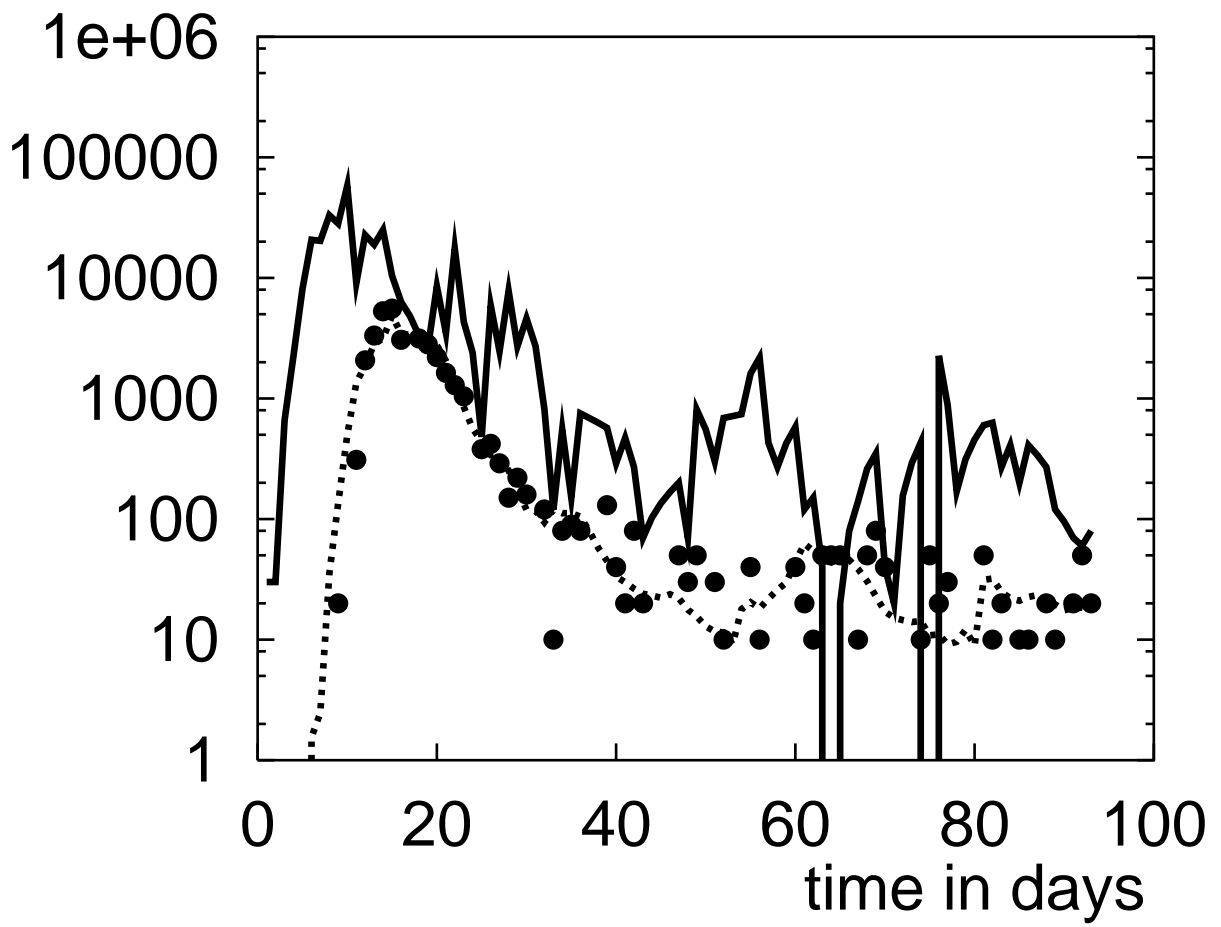
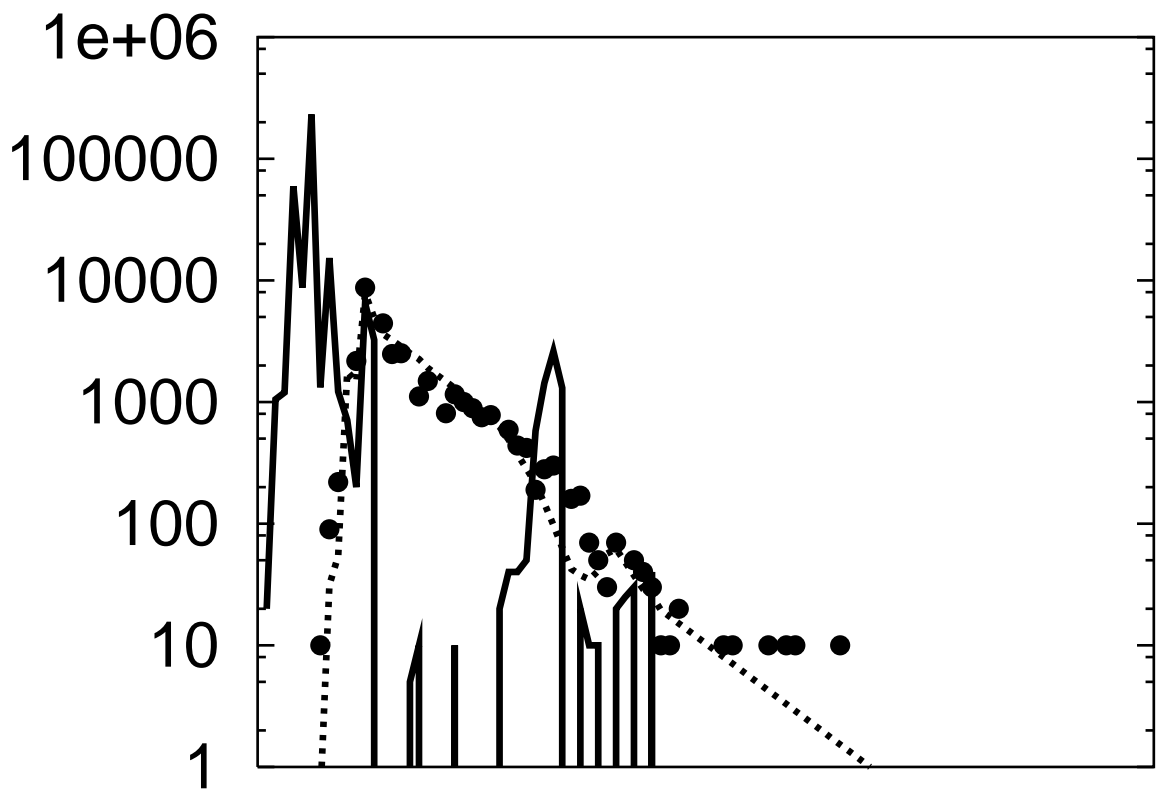
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



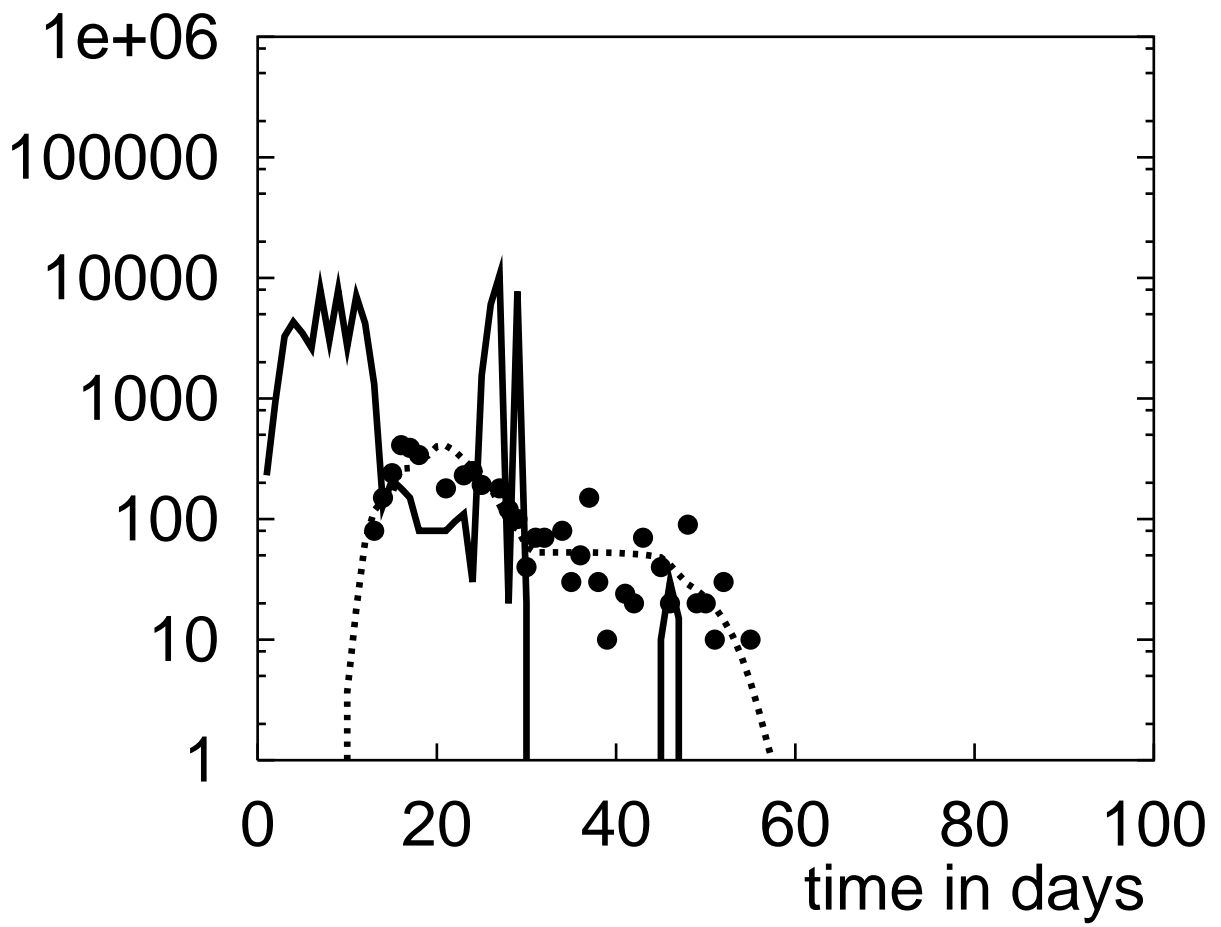
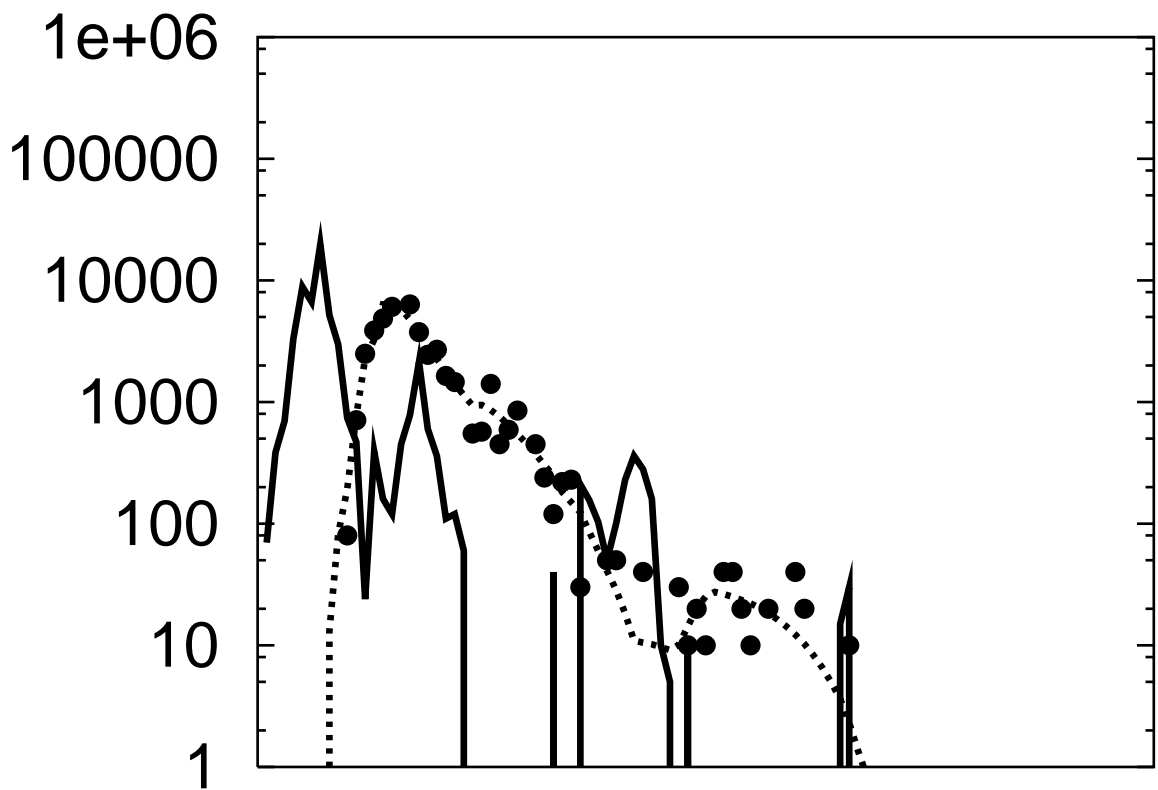
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observ. gameto. •
expect gameto. ·····

parasites per μl blood



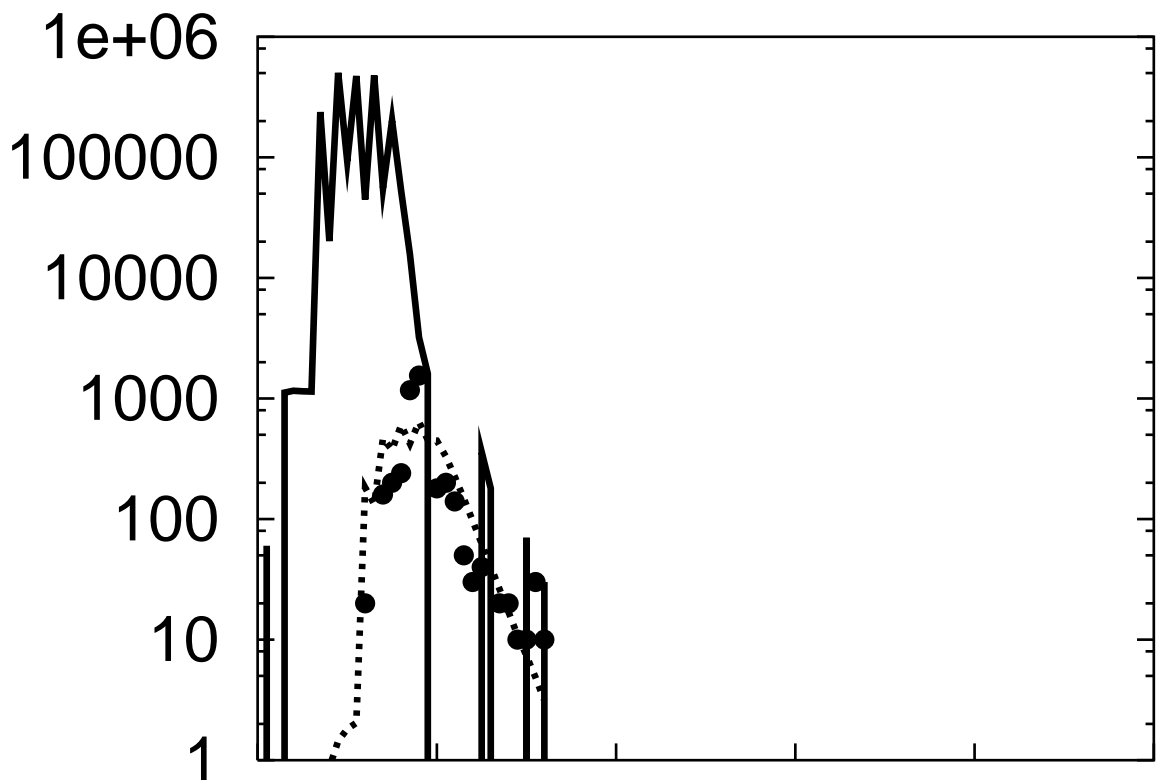
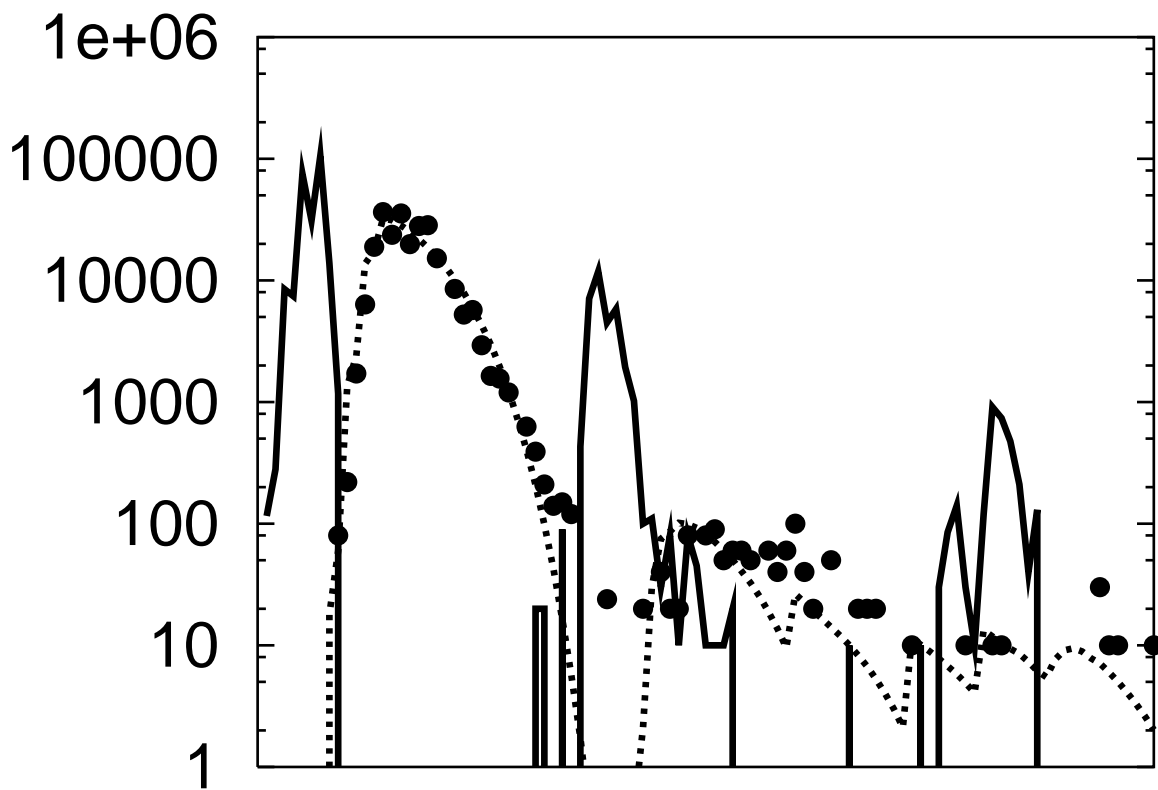
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



asex. parasites ———
observ. gameto. •
expect gameto. ·····

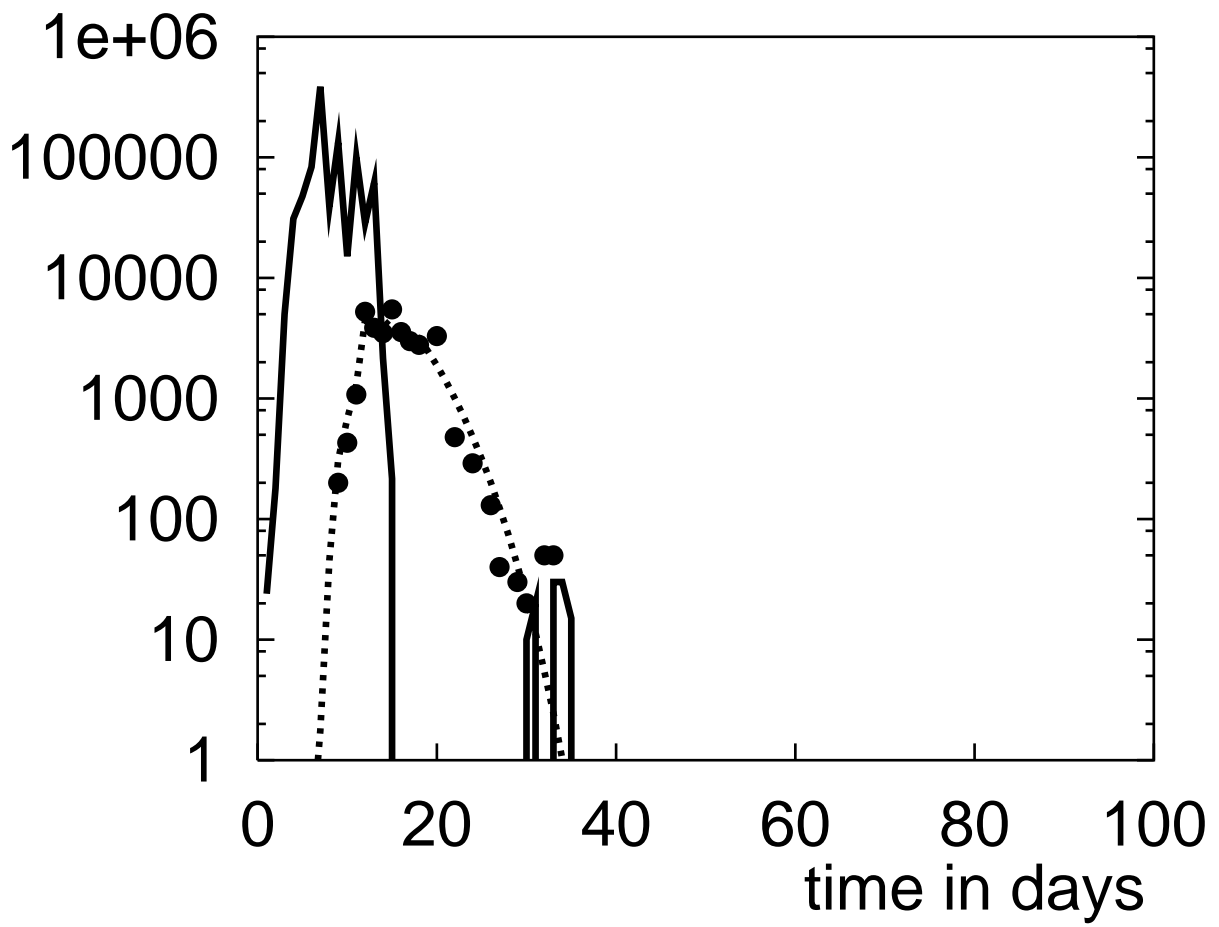
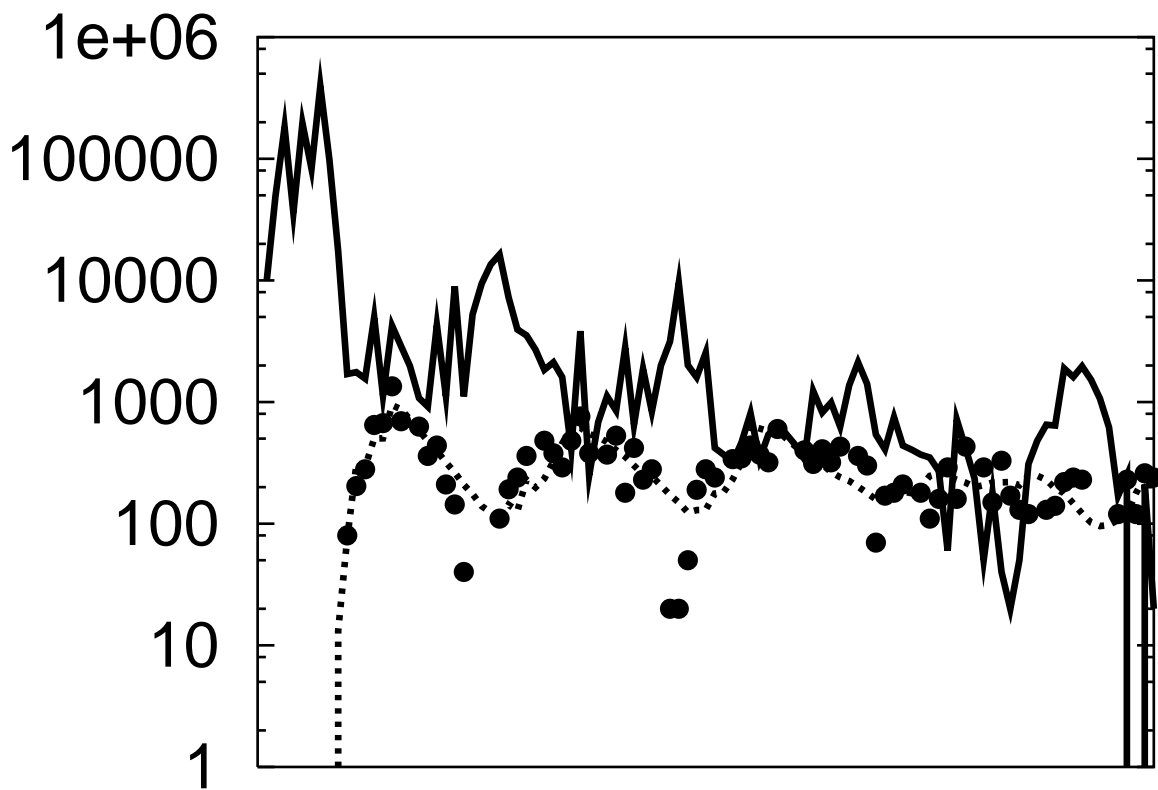
parasites per μl blood



0 20 40 60 80 100
time in days

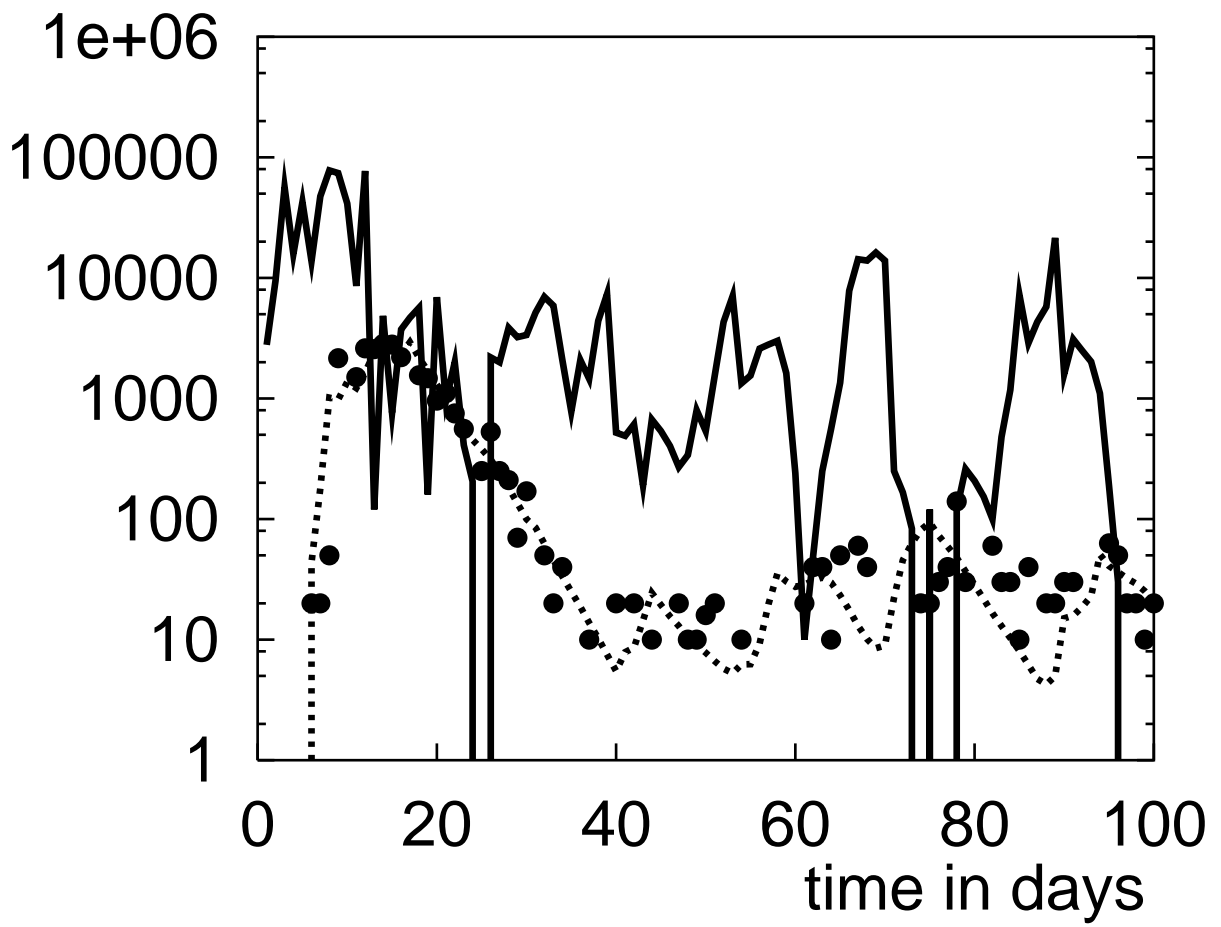
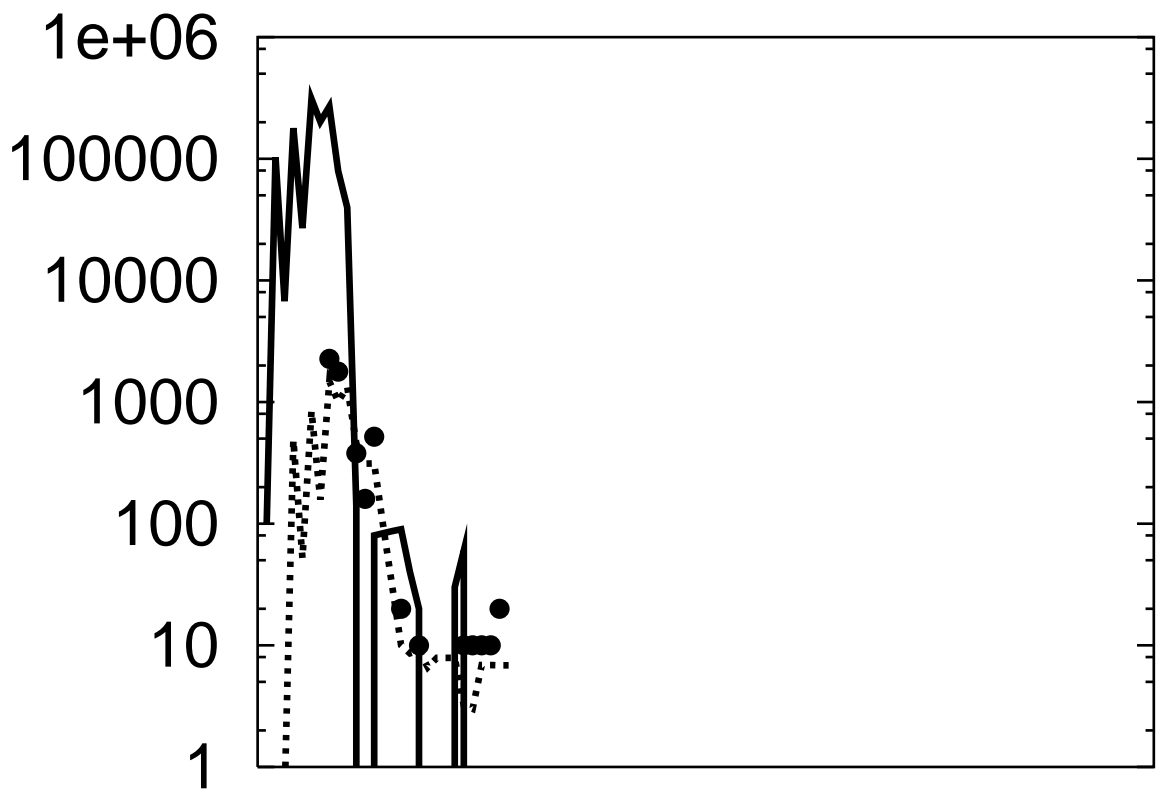
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observ. gameto. •
expect gameto. ·····

parasites per μl blood



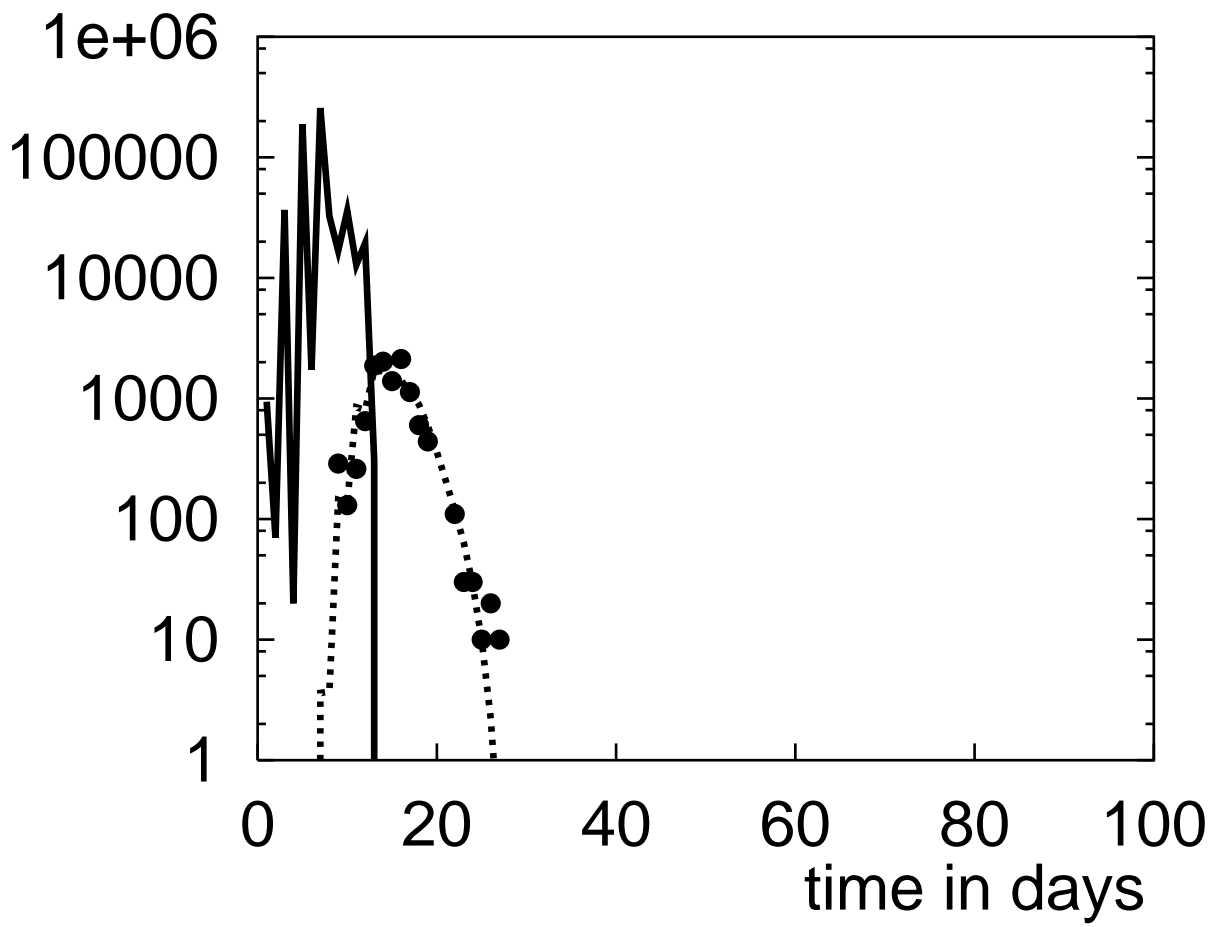
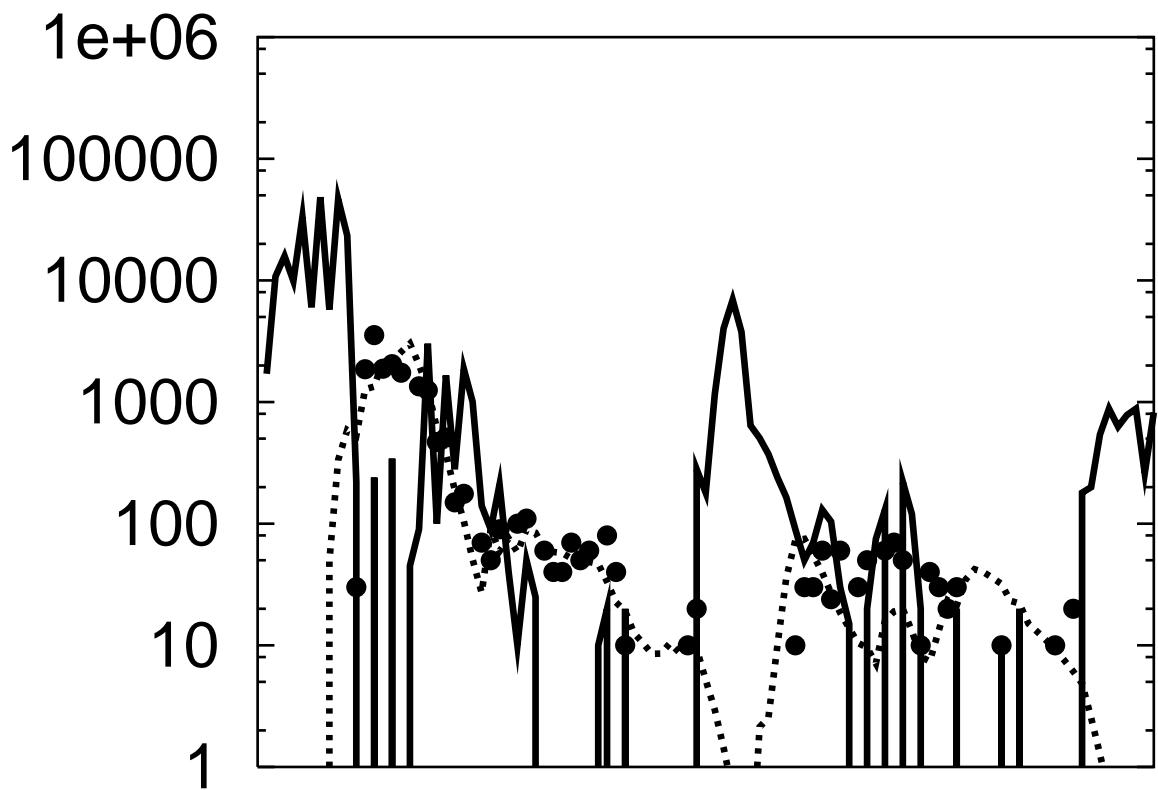
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observ. gameto. •
expect gameto. ···

parasites per μl blood



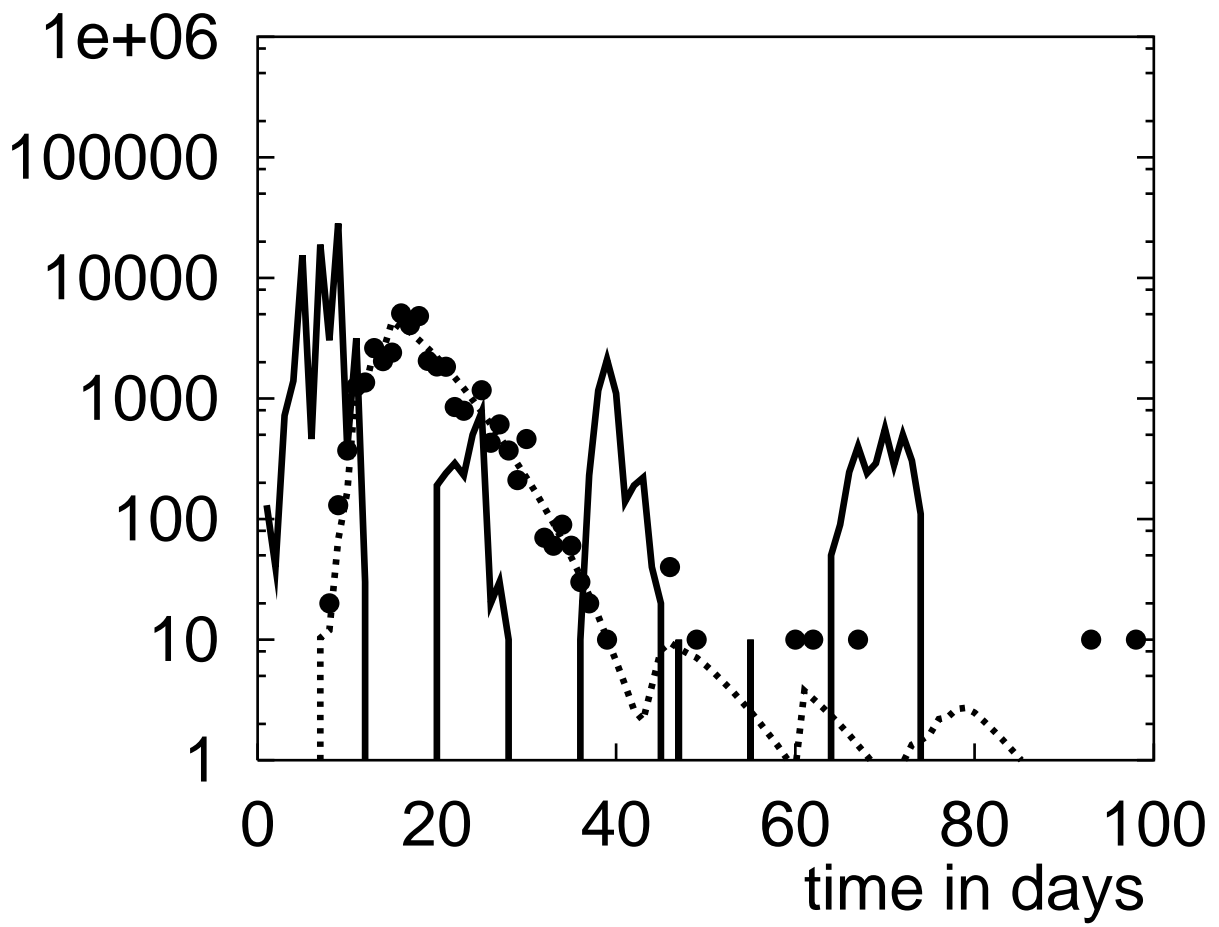
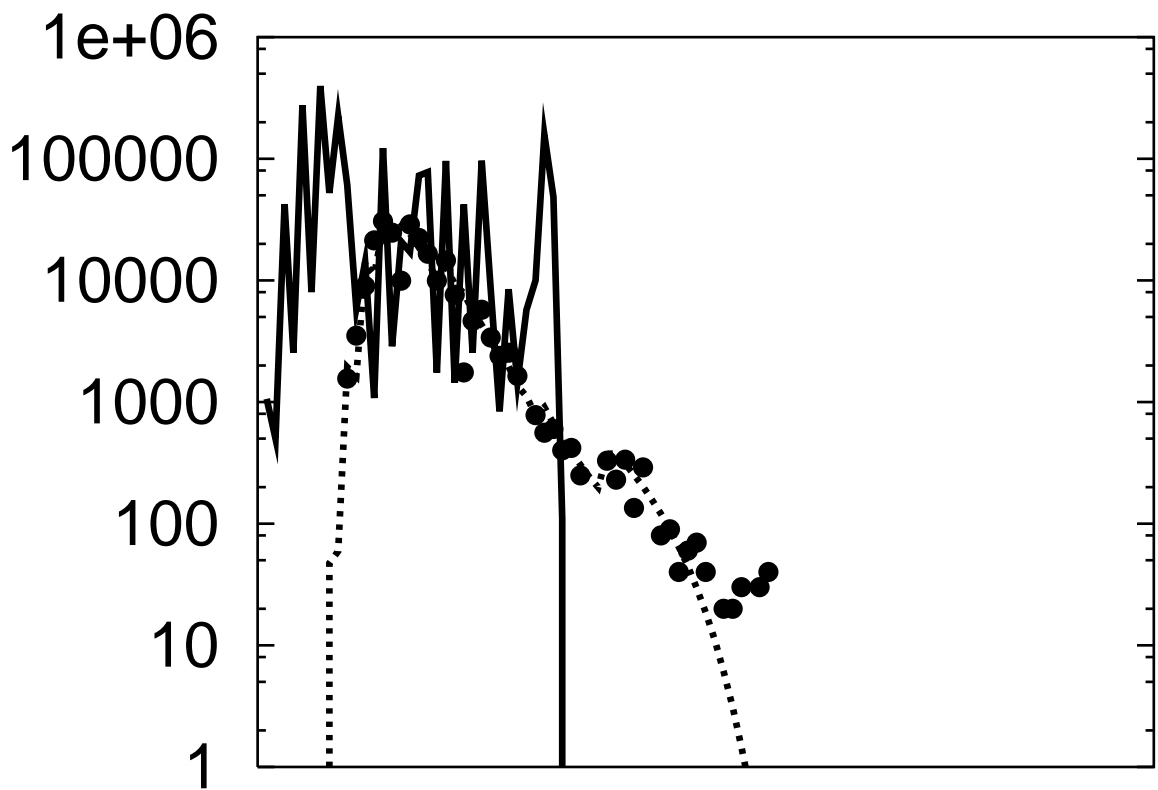
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observ. gameto. •
expect gameto. ···

parasites per μl blood



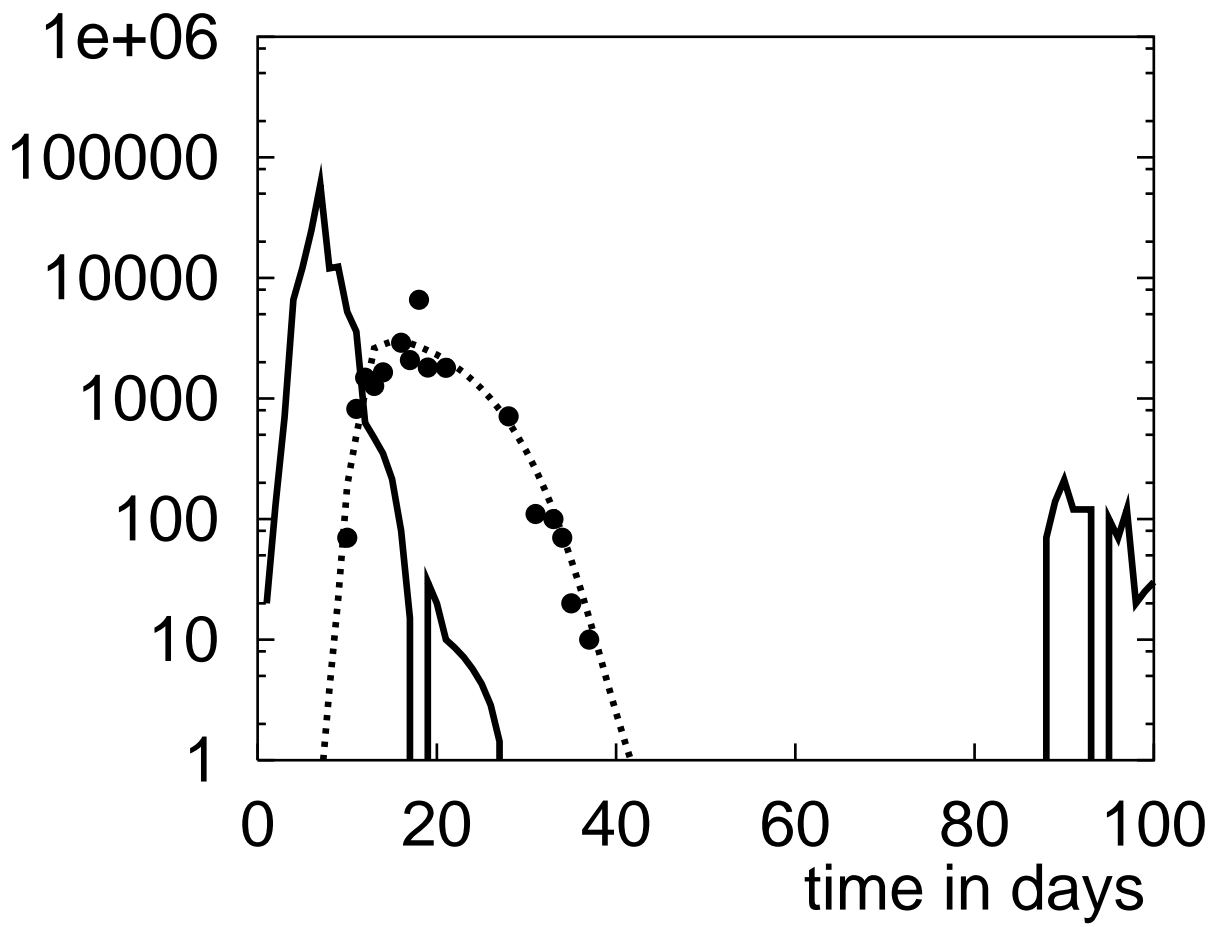
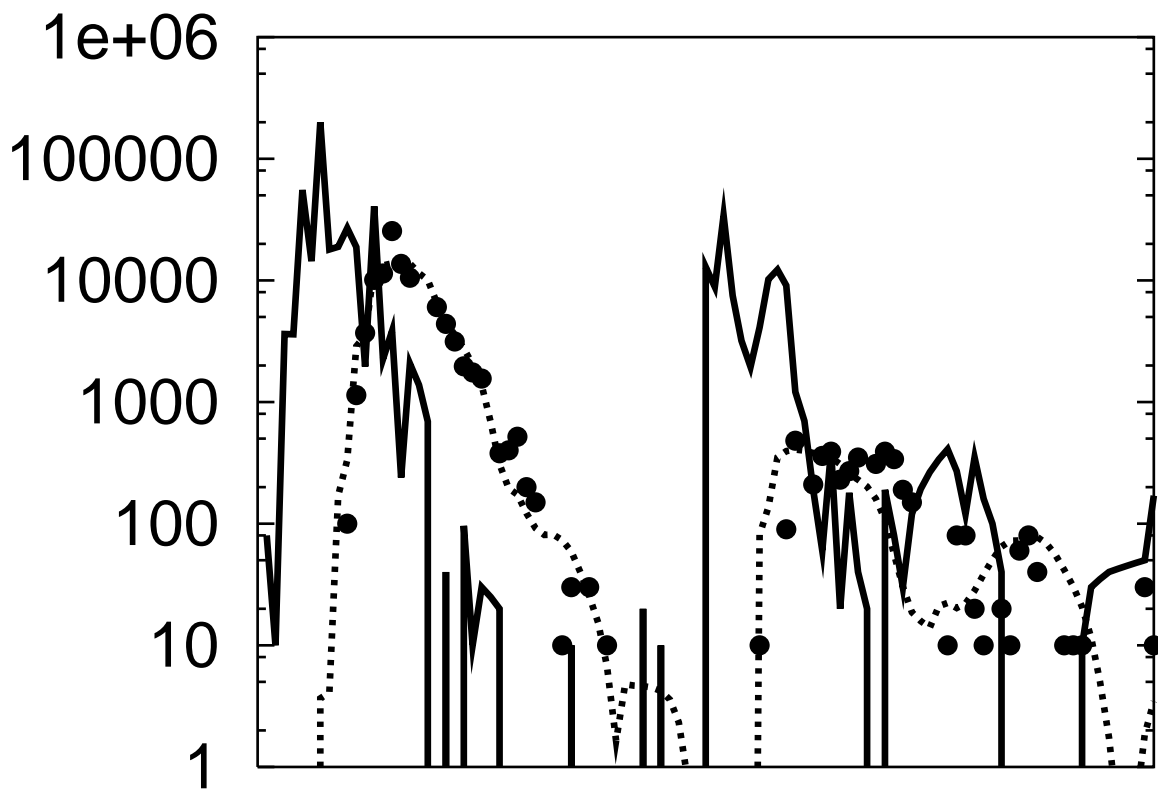
asex. parasites —
observ. gameto. •
expect gameto. ·····

parasites per μl blood



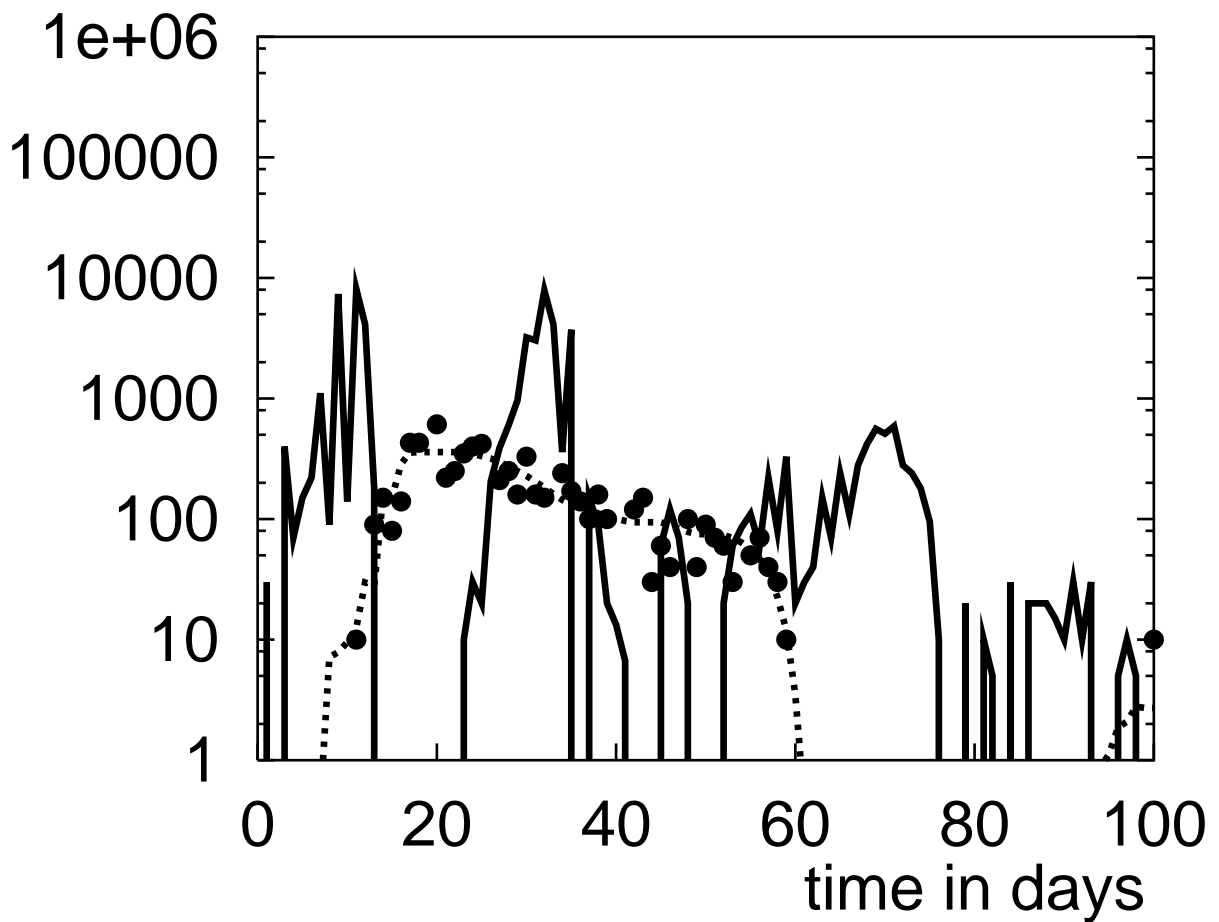
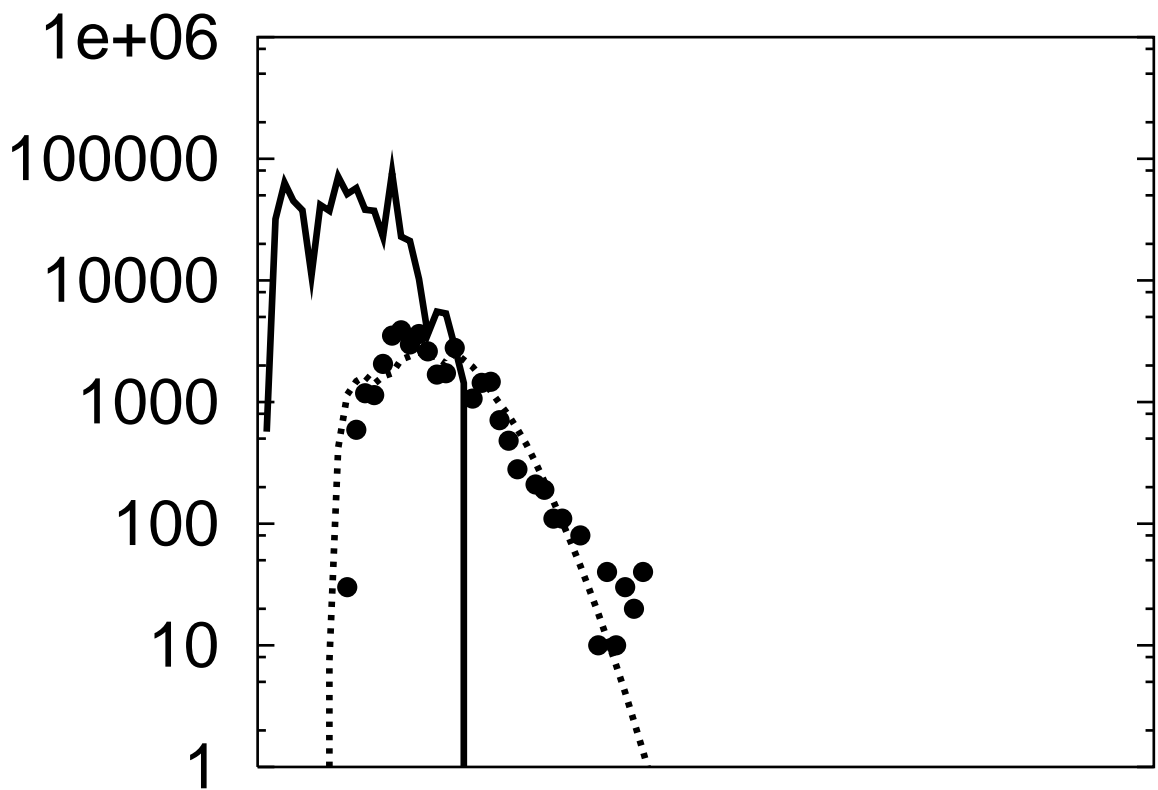
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observ. gameto. •
expect gameto. ·····

parasites per μl blood



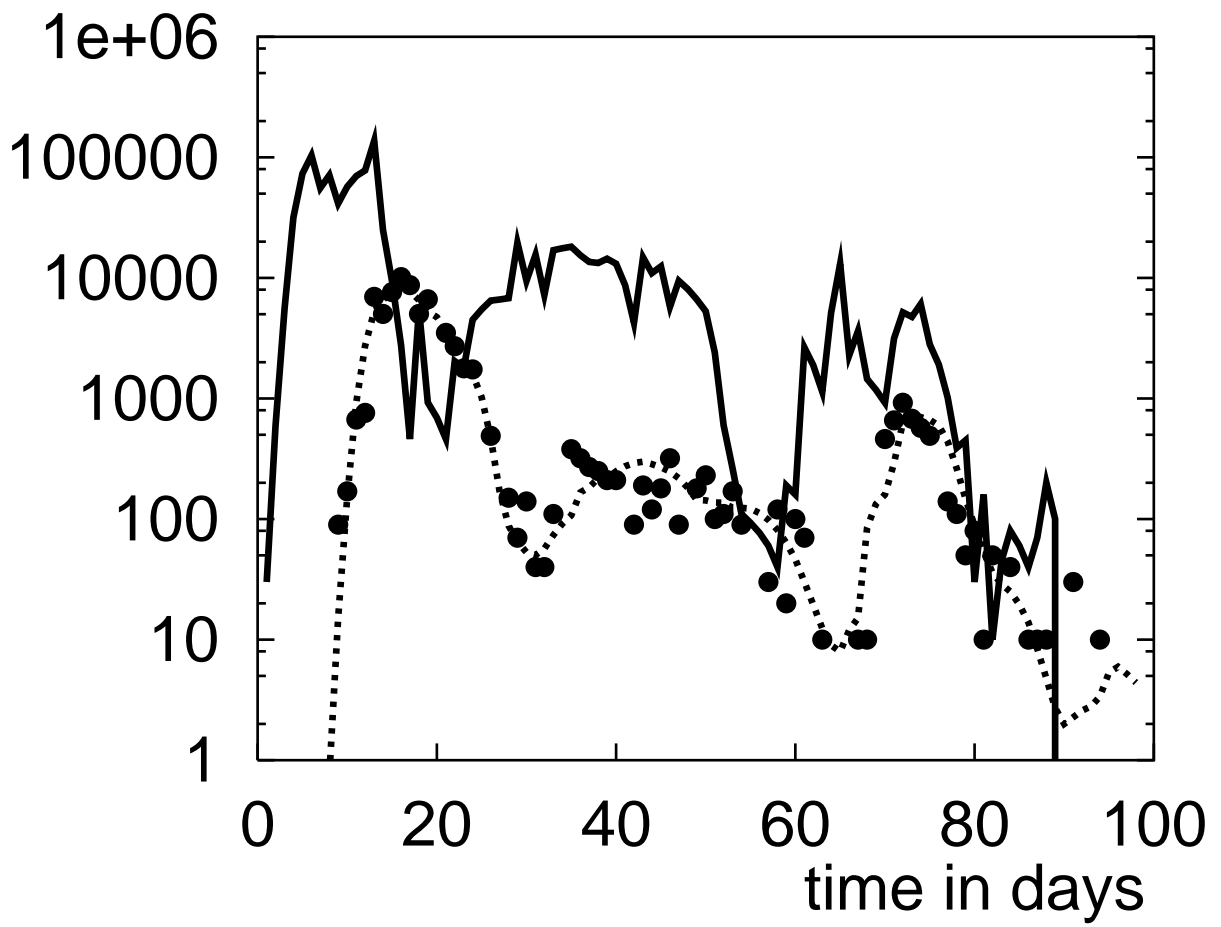
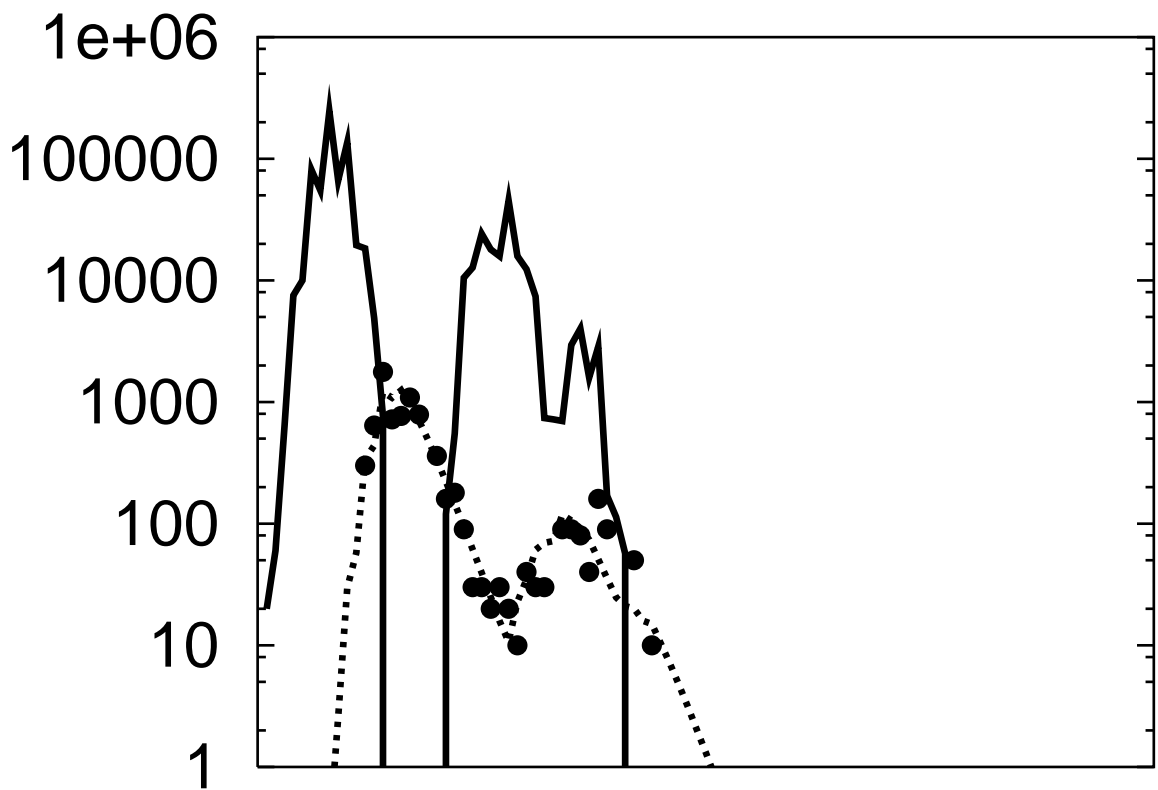
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



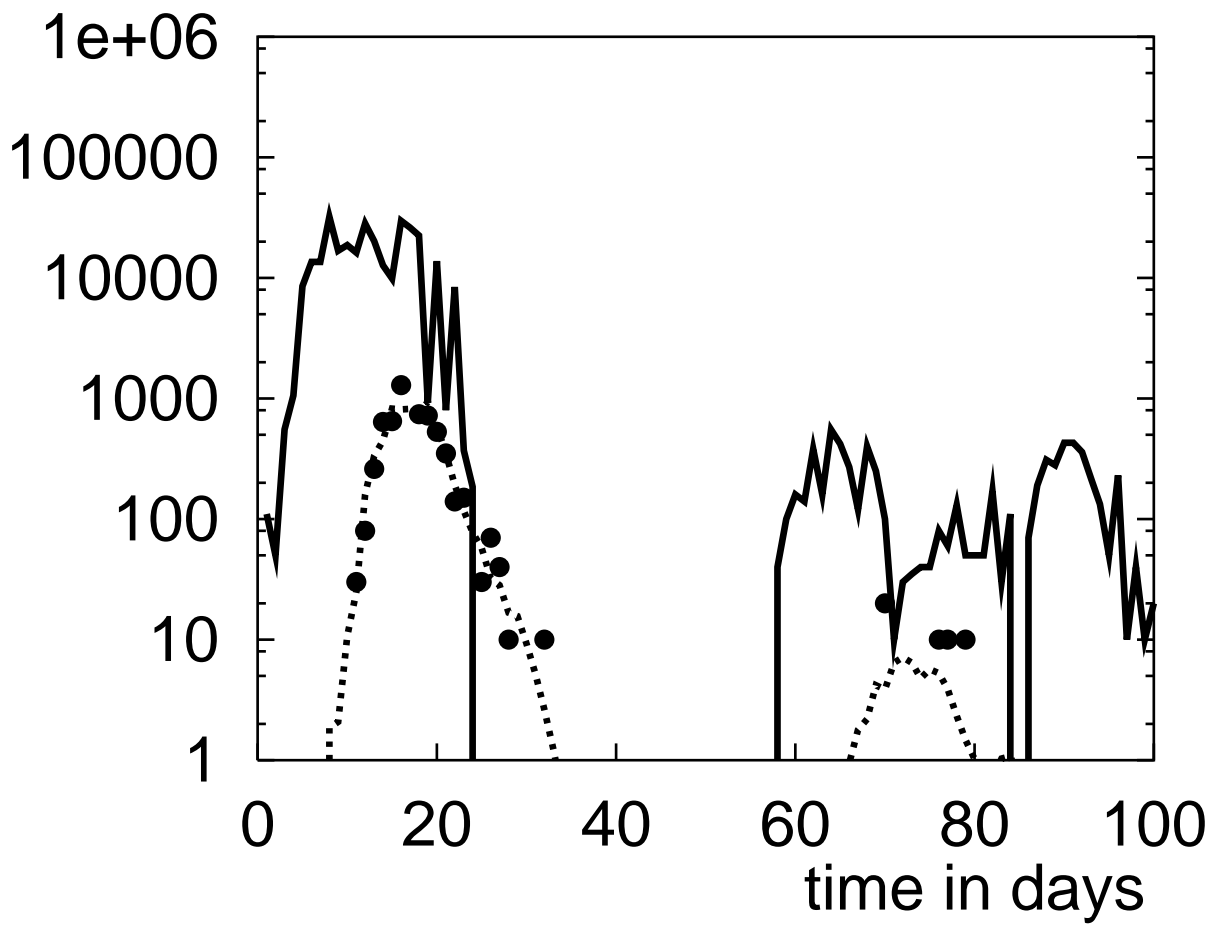
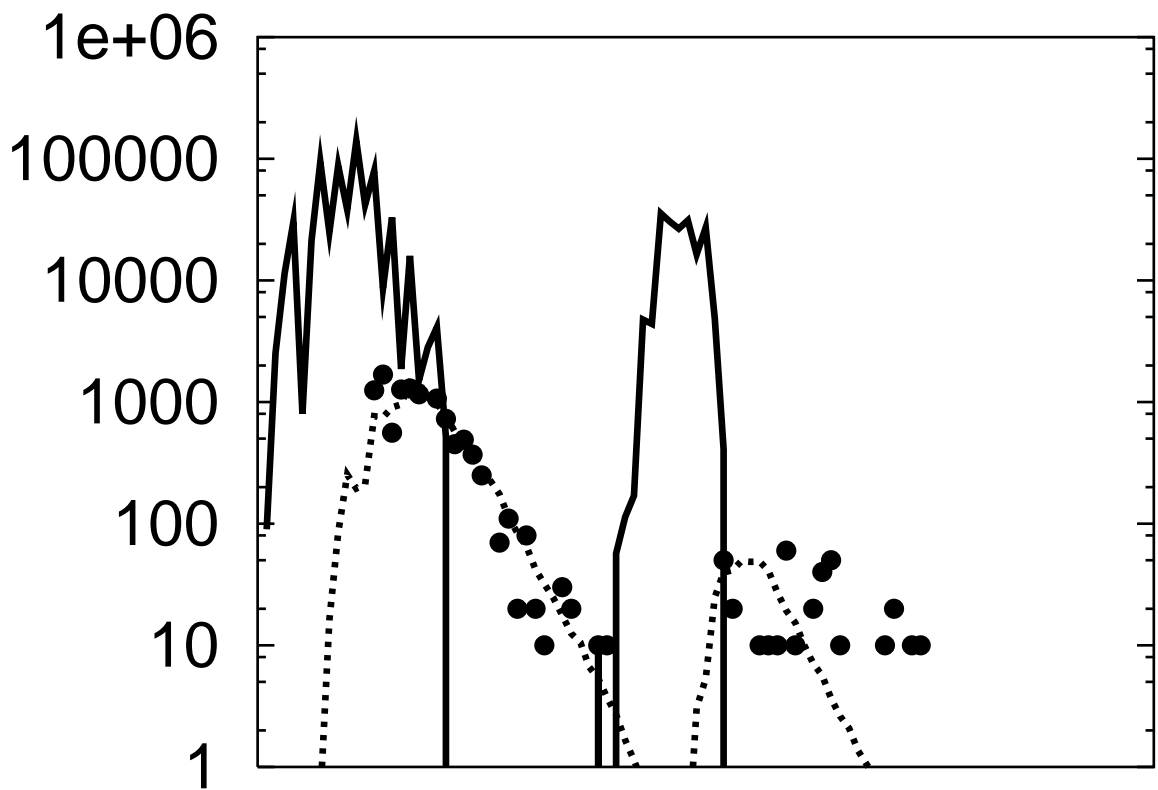
asex. parasites —
observ. gameto. •
expect gameto. ·····

parasites per μl blood



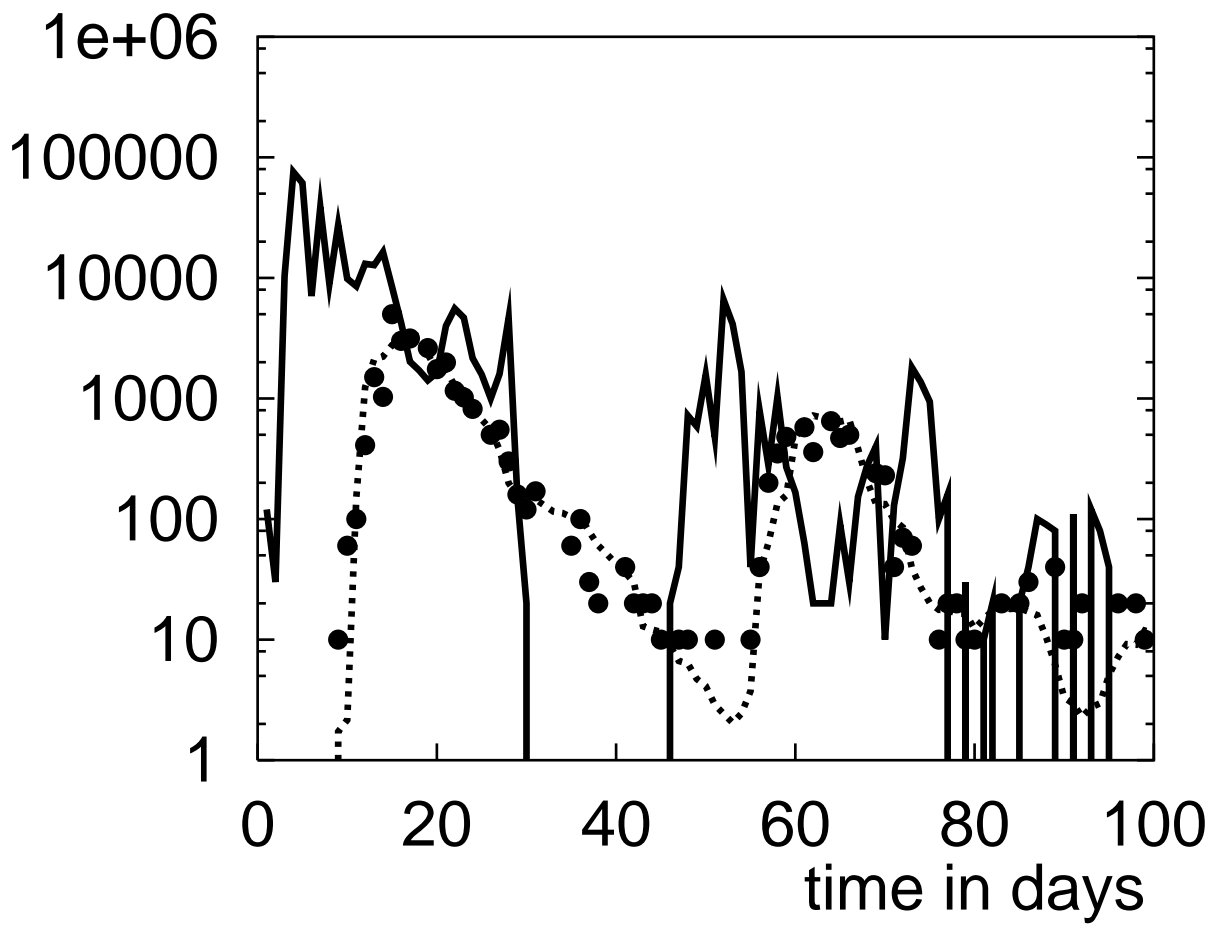
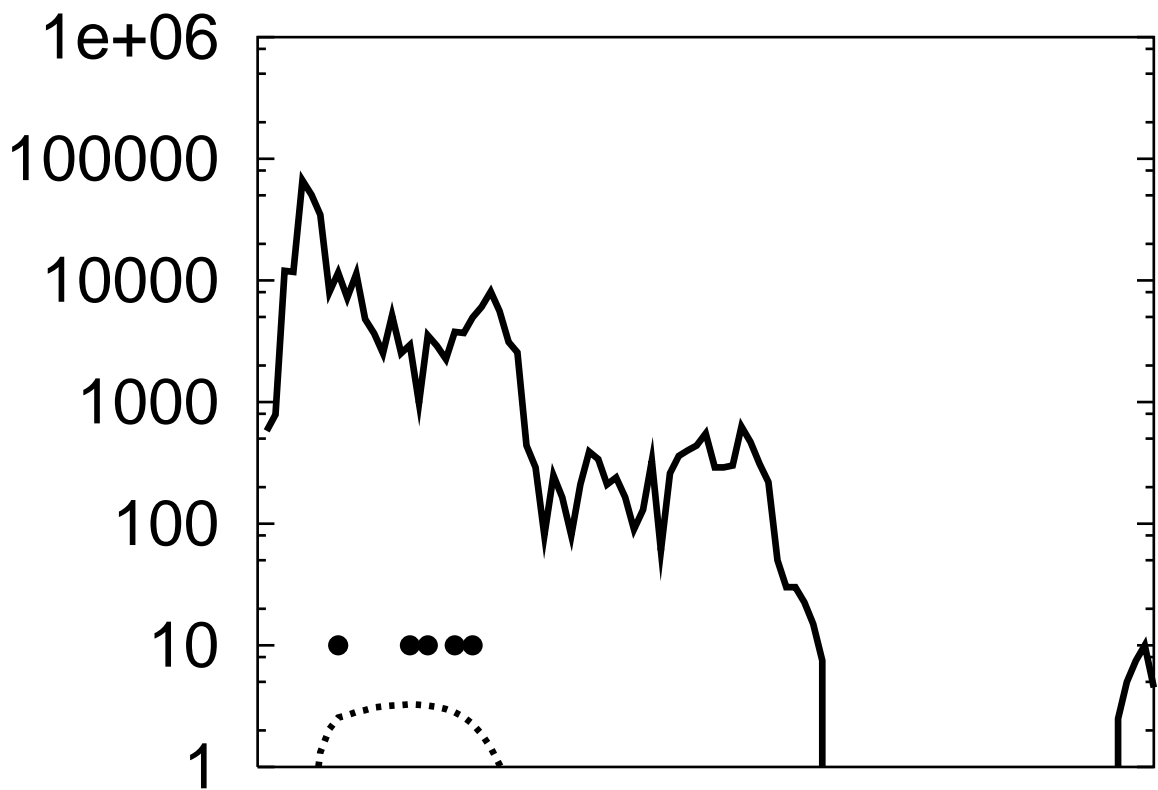
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



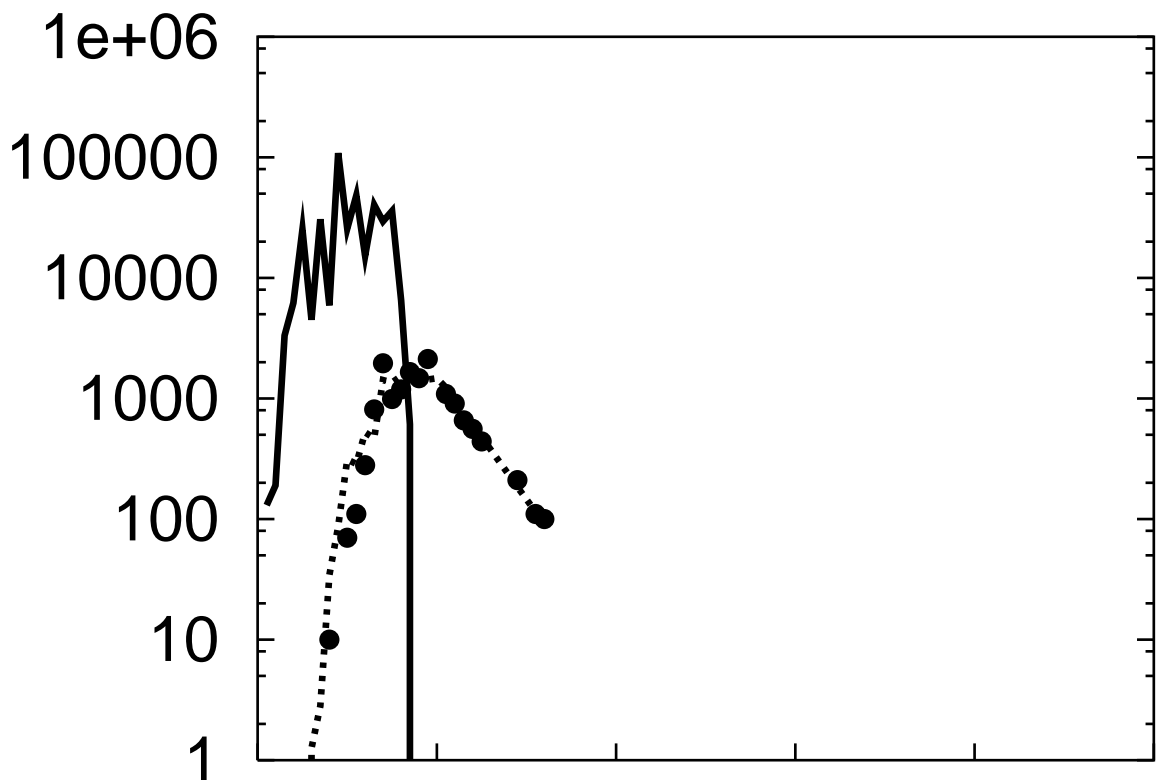
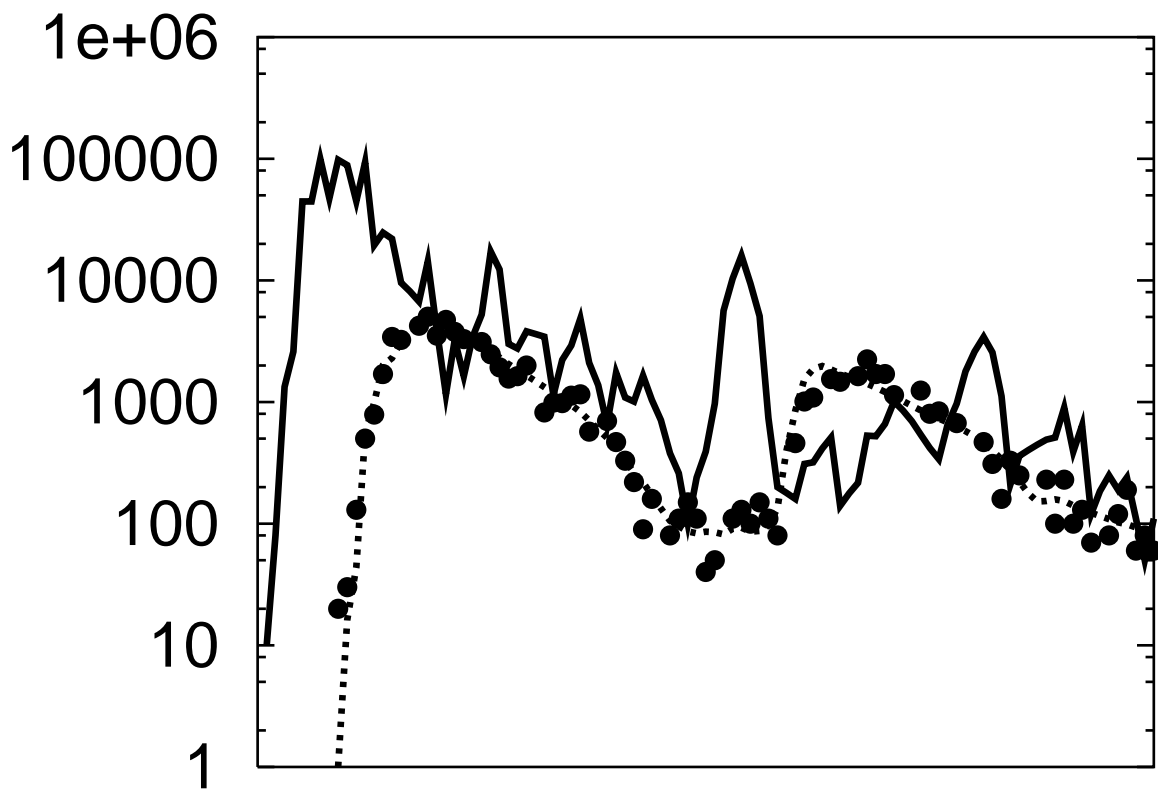
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



asex. parasites ———
observ. gameto. •
expect gameto. ·····

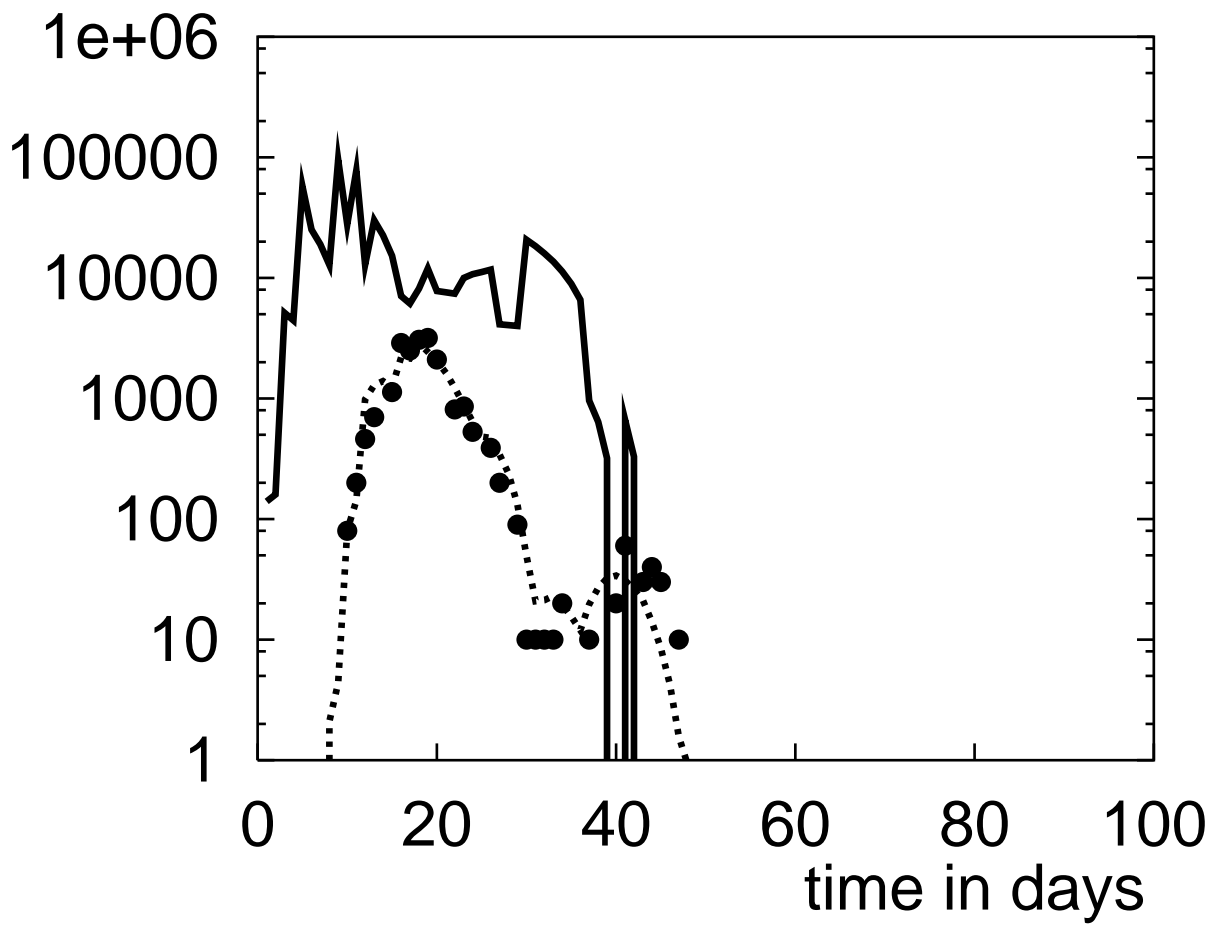
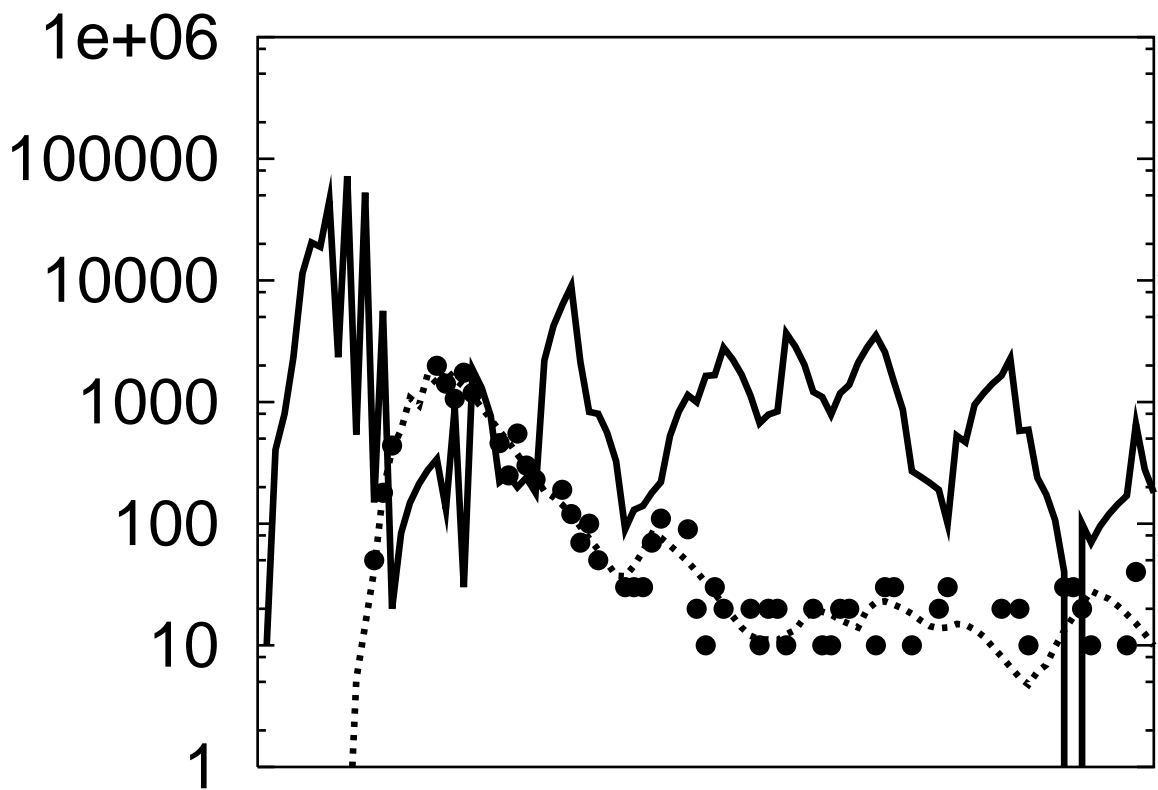
parasites per μl blood



0 20 40 60 80 100
time in days

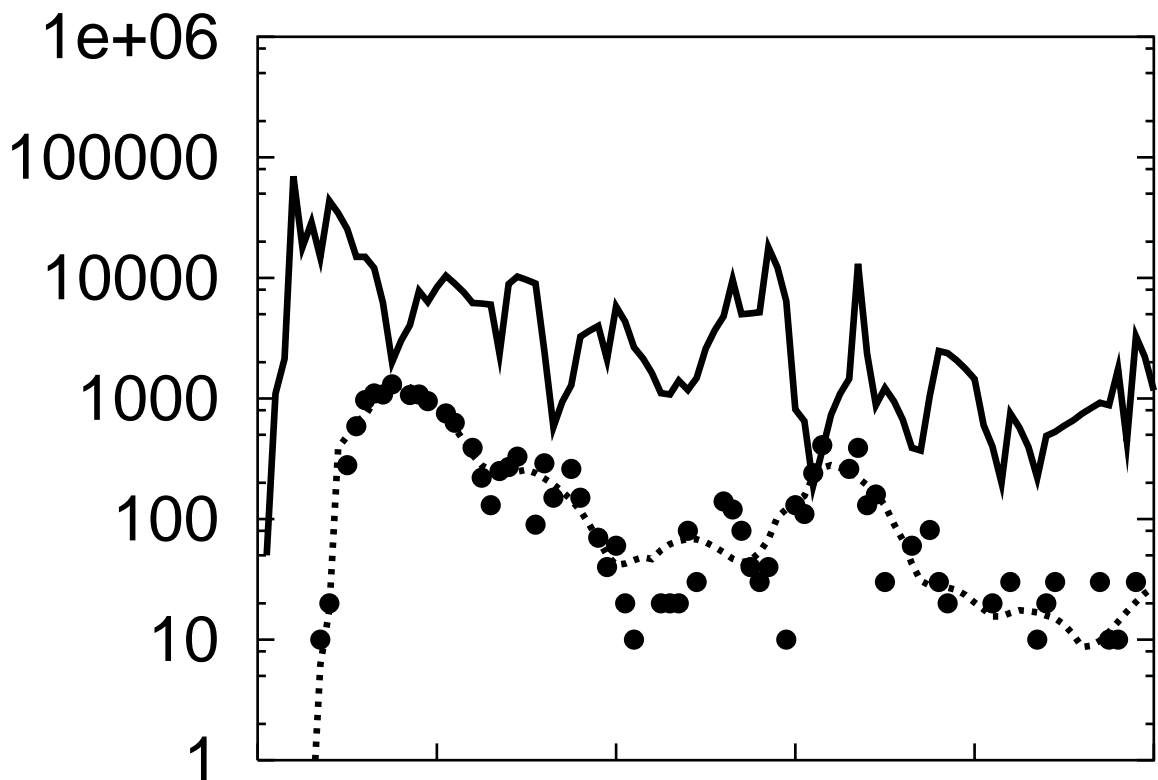
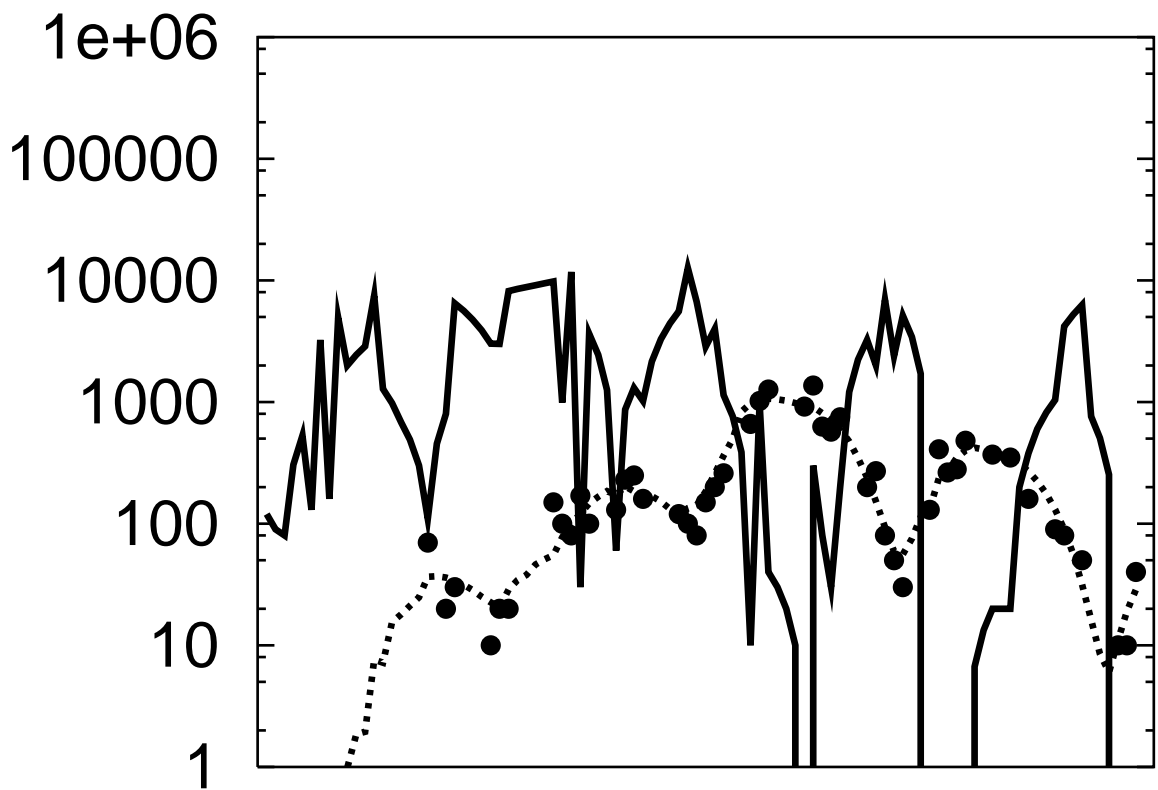
asex. parasites —
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expect gameto. ·····

parasites per μl blood



asex. parasites —
observ. gameto. •
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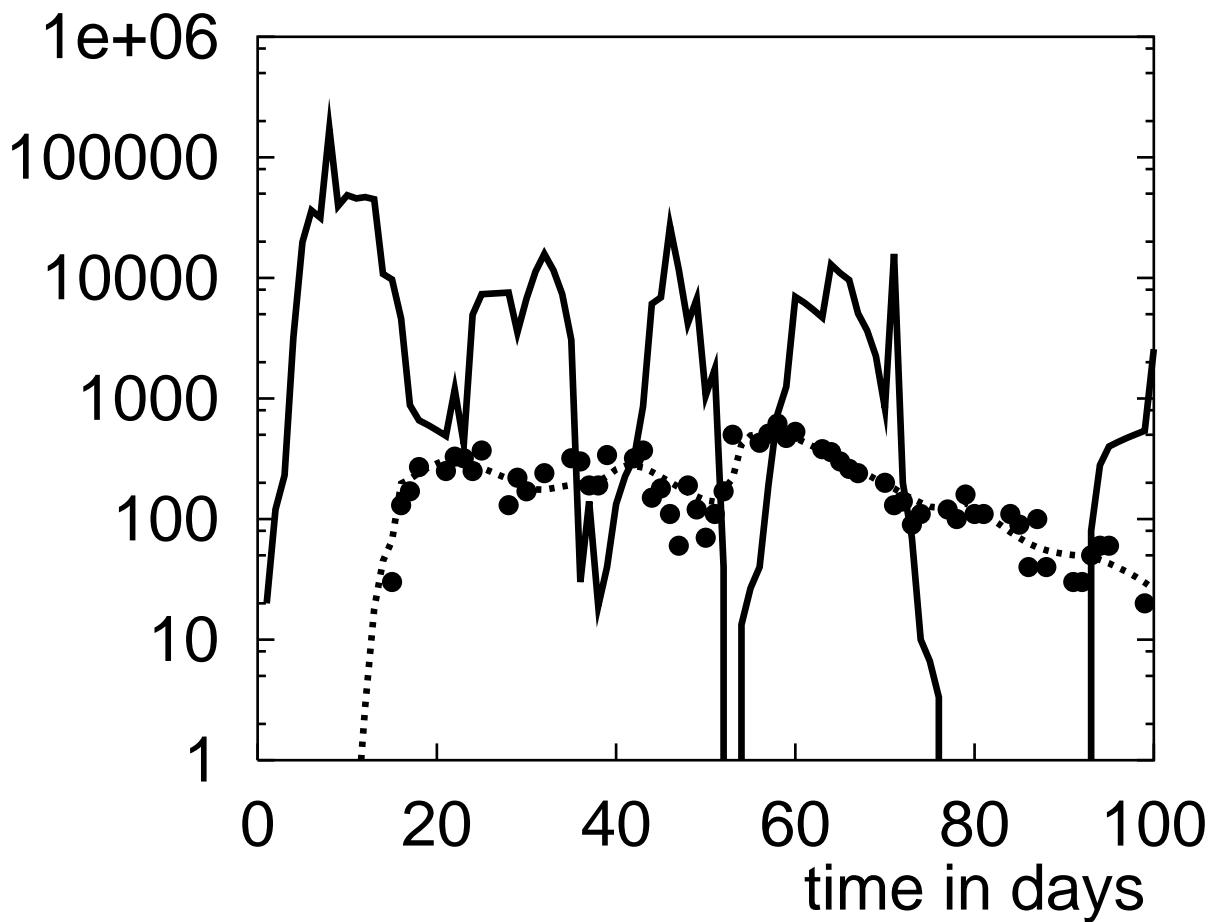
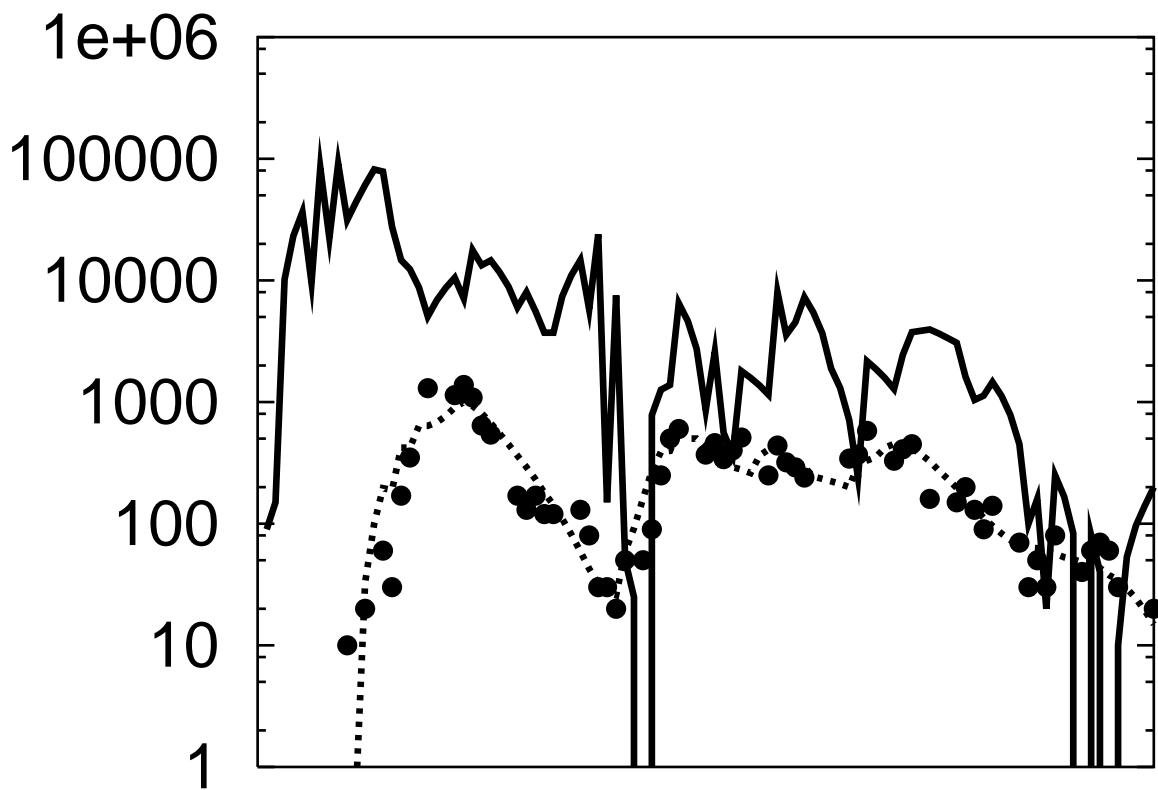
parasites per μl blood



0 20 40 60 80 100
time in days

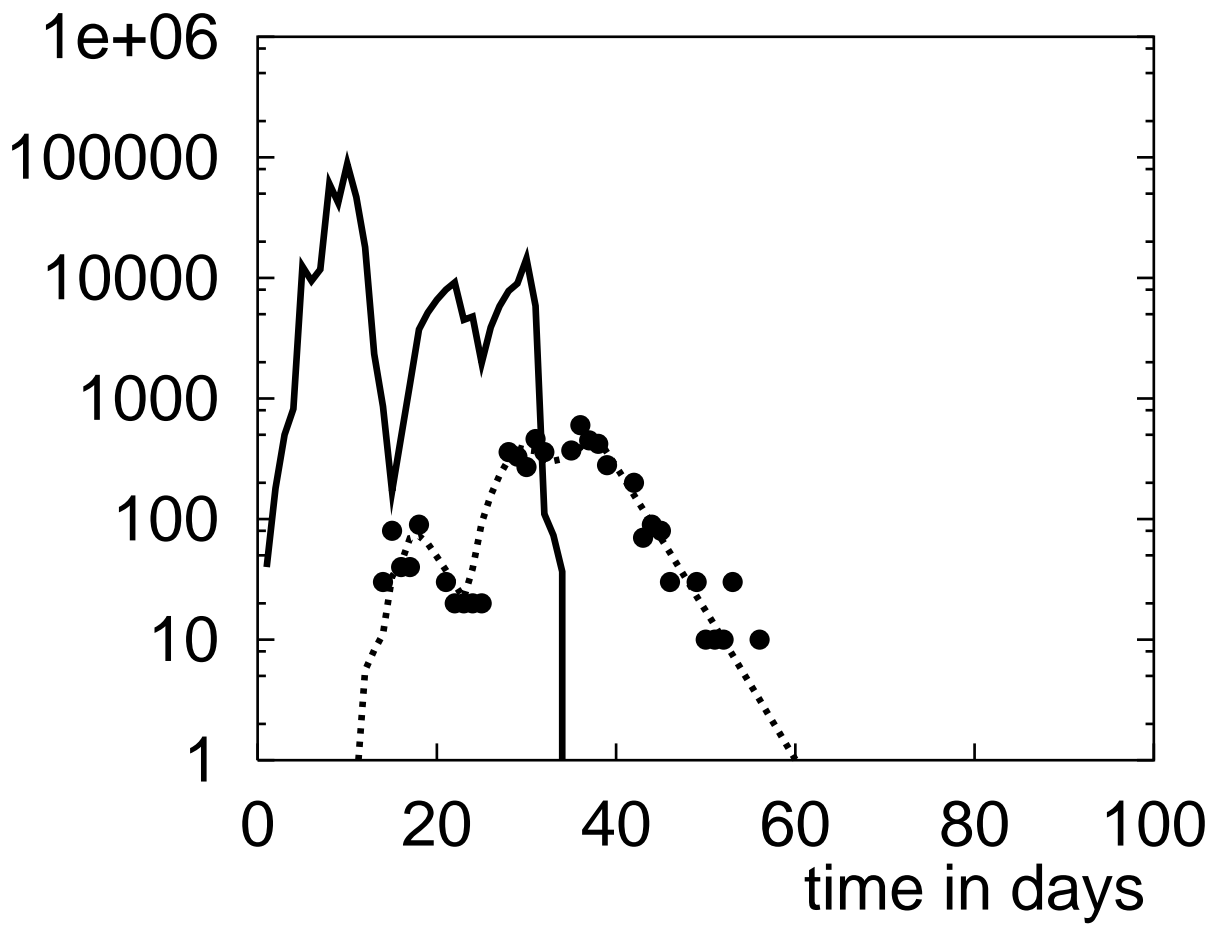
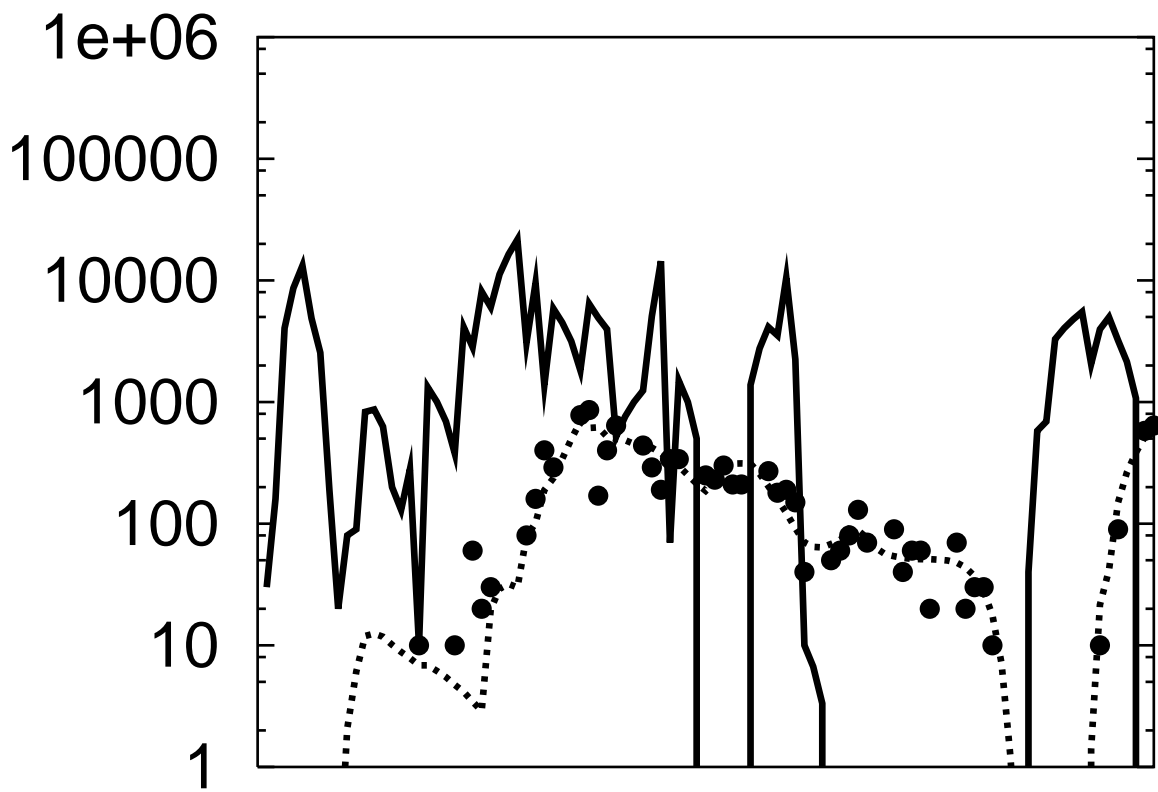
asex. parasites —
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parasites per μl blood



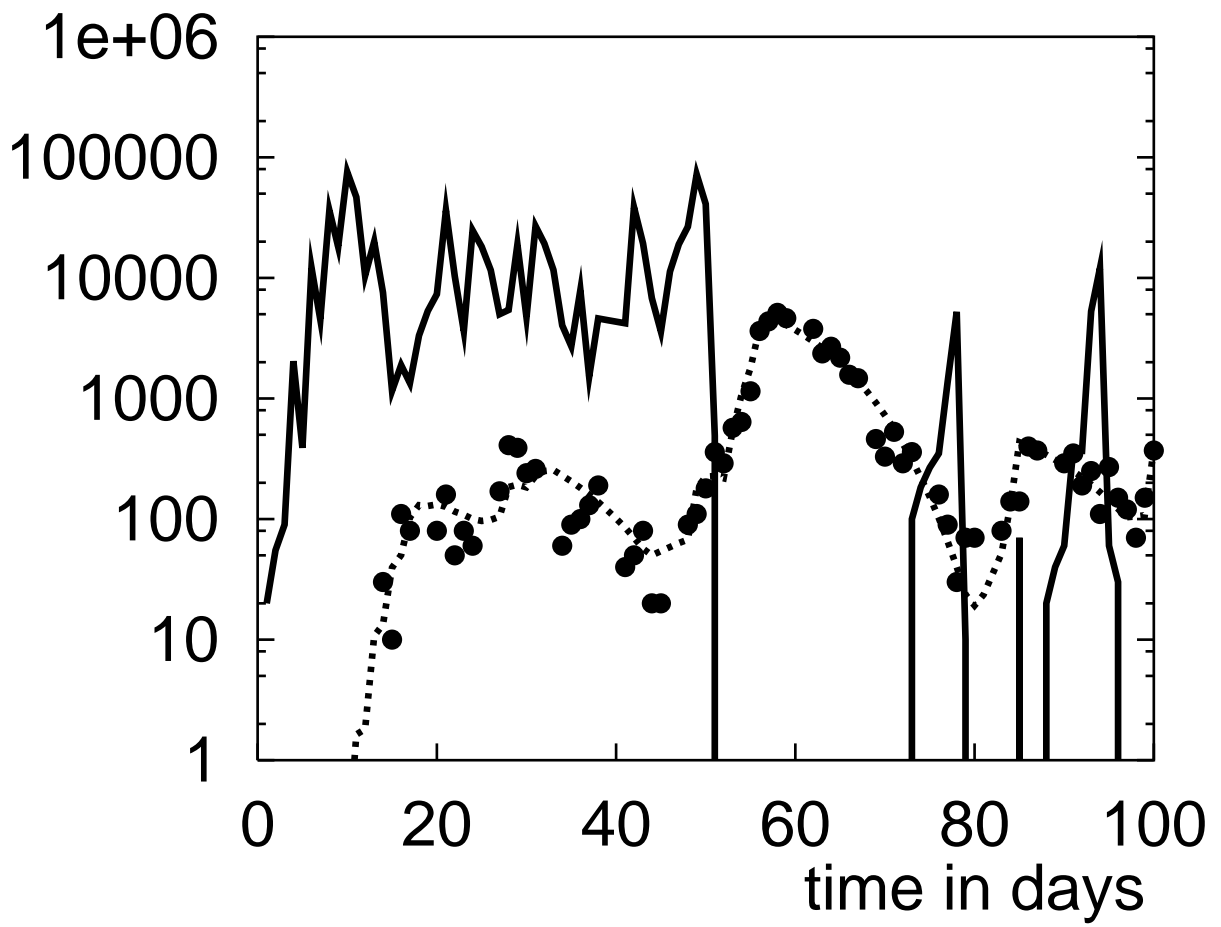
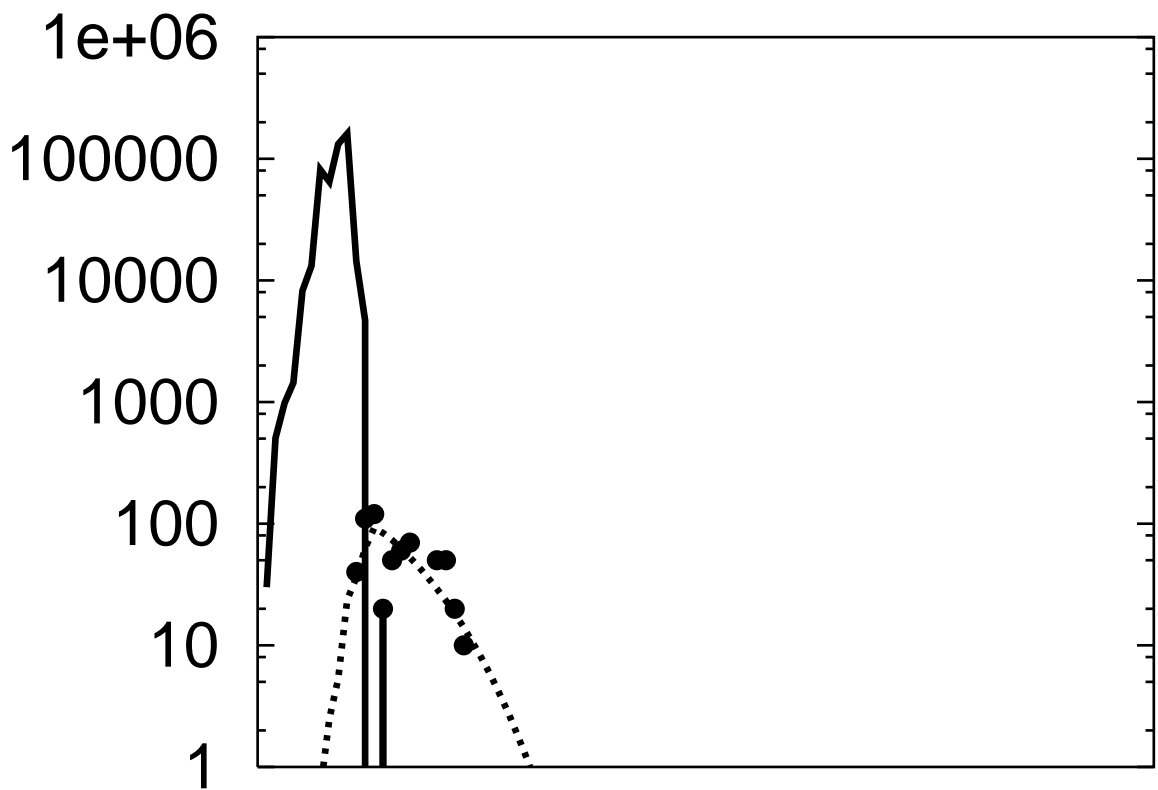
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



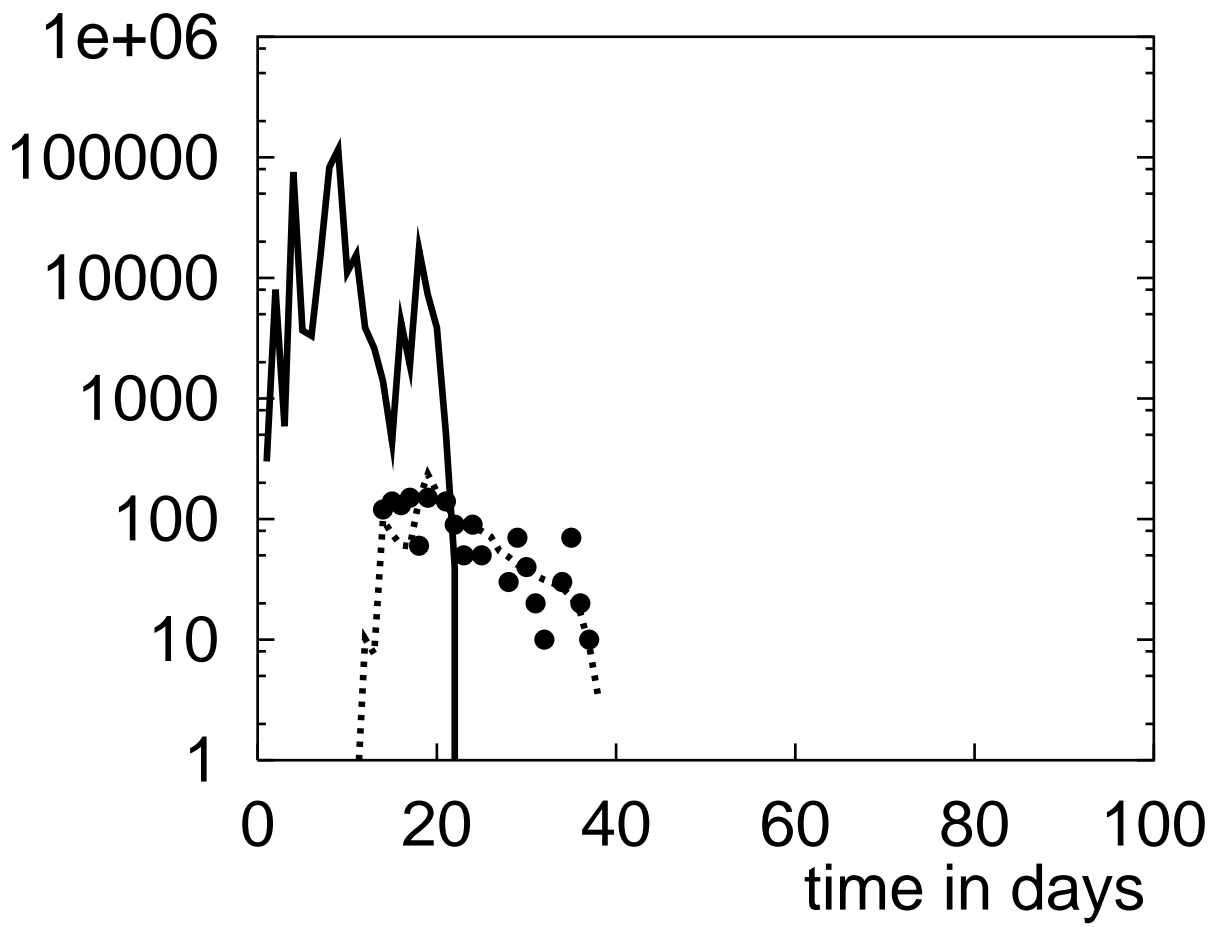
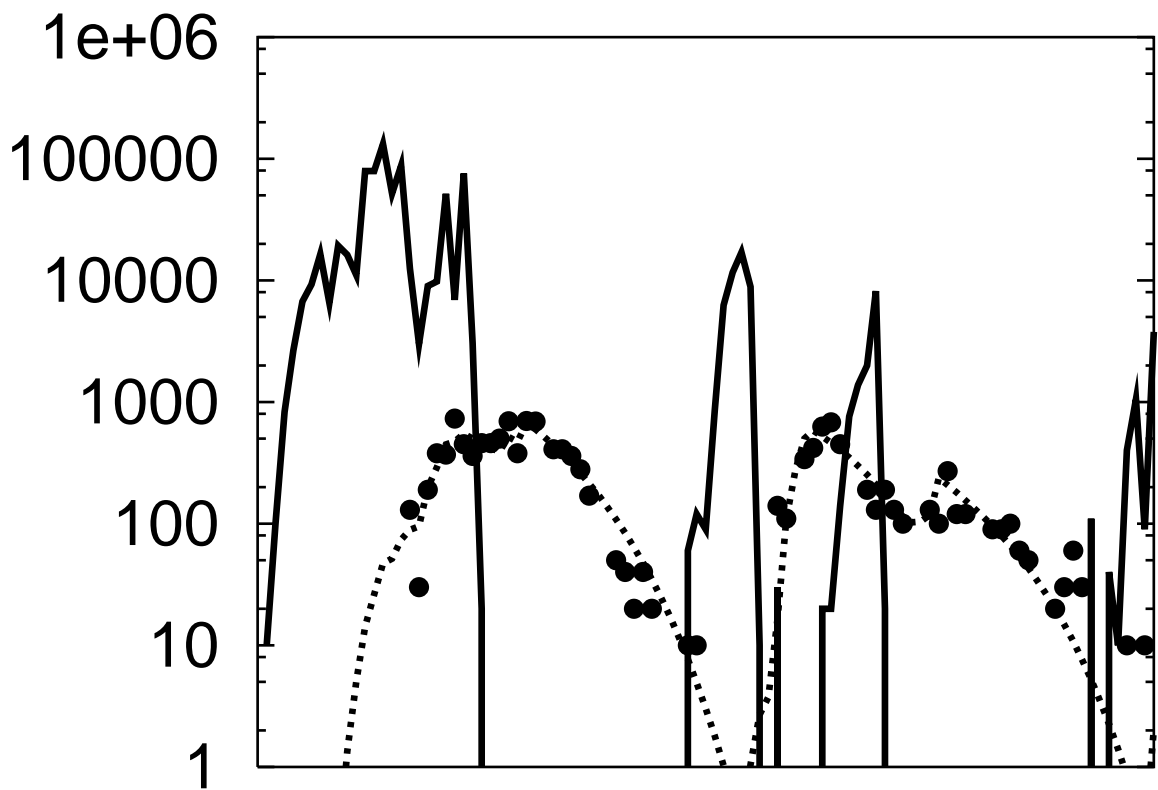
asex. parasites —
observ. gameto. •
expect gameto. ···

parasites per μl blood



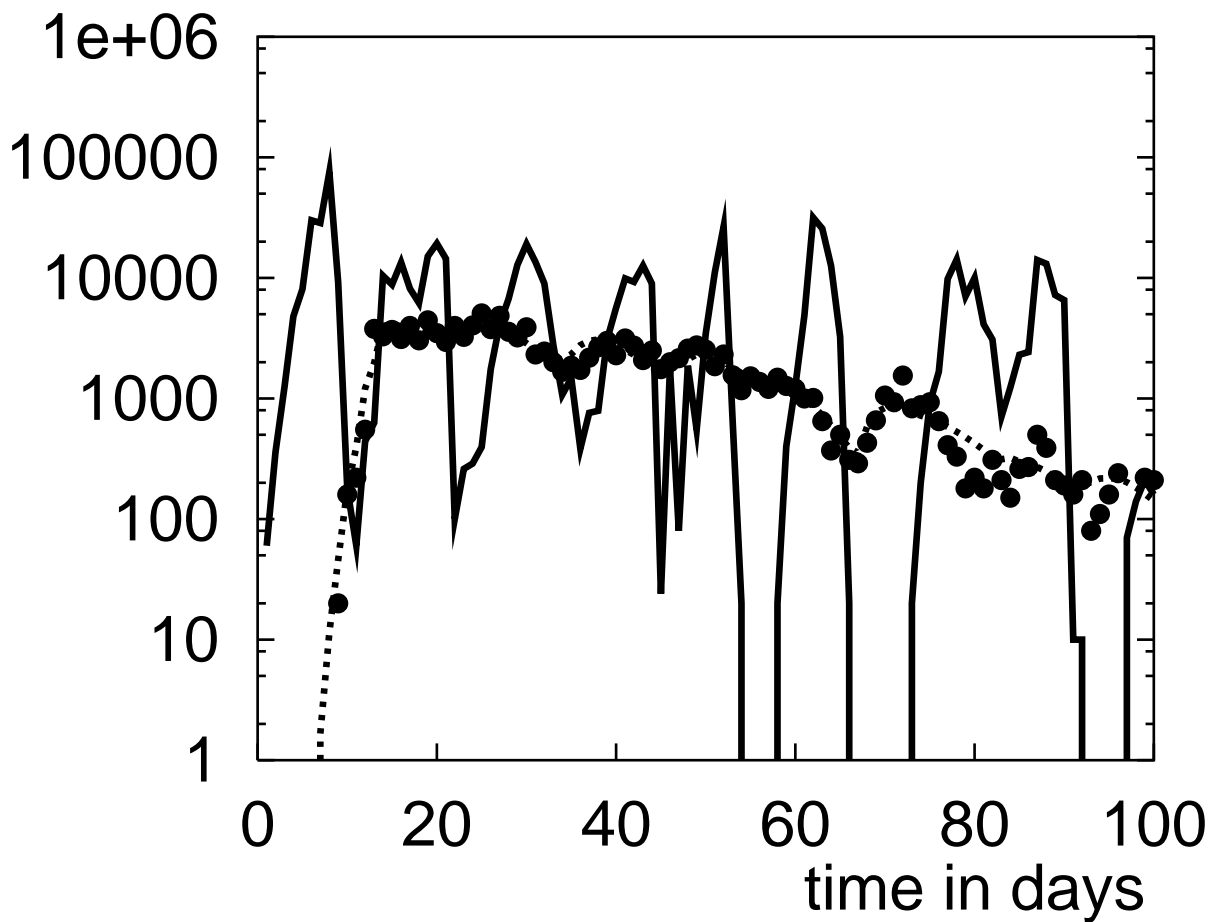
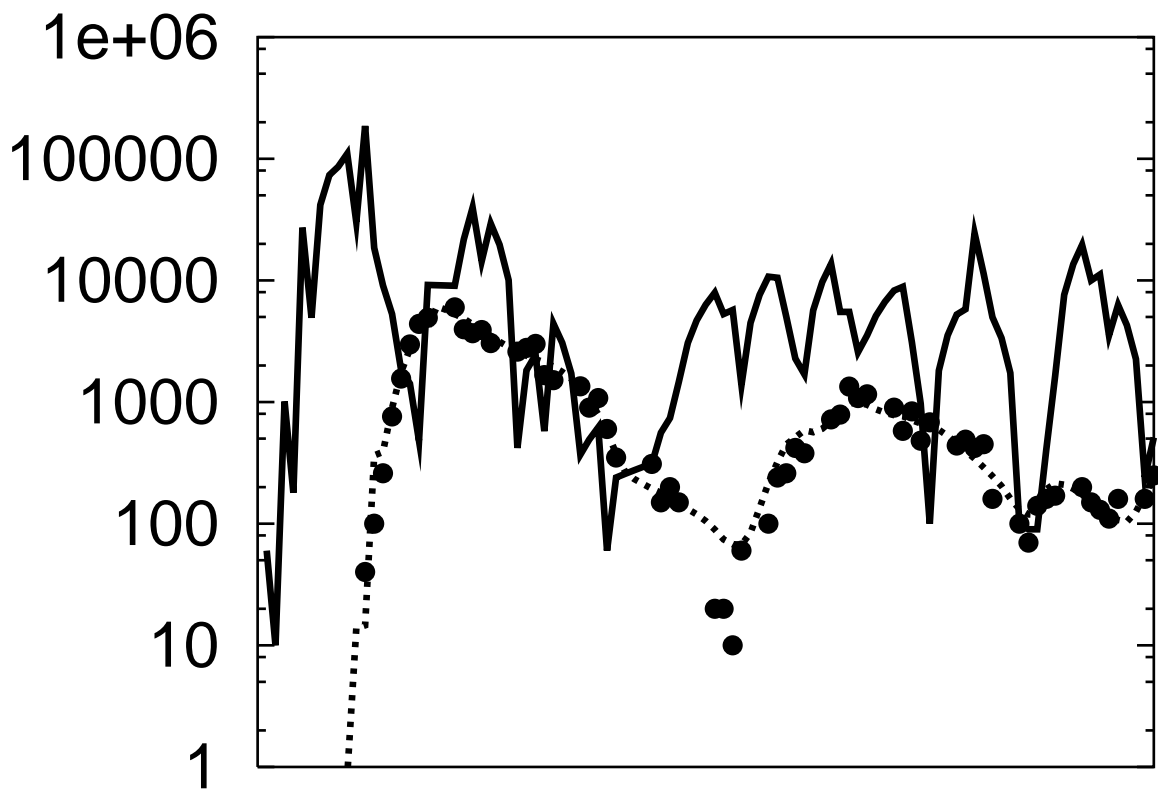
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



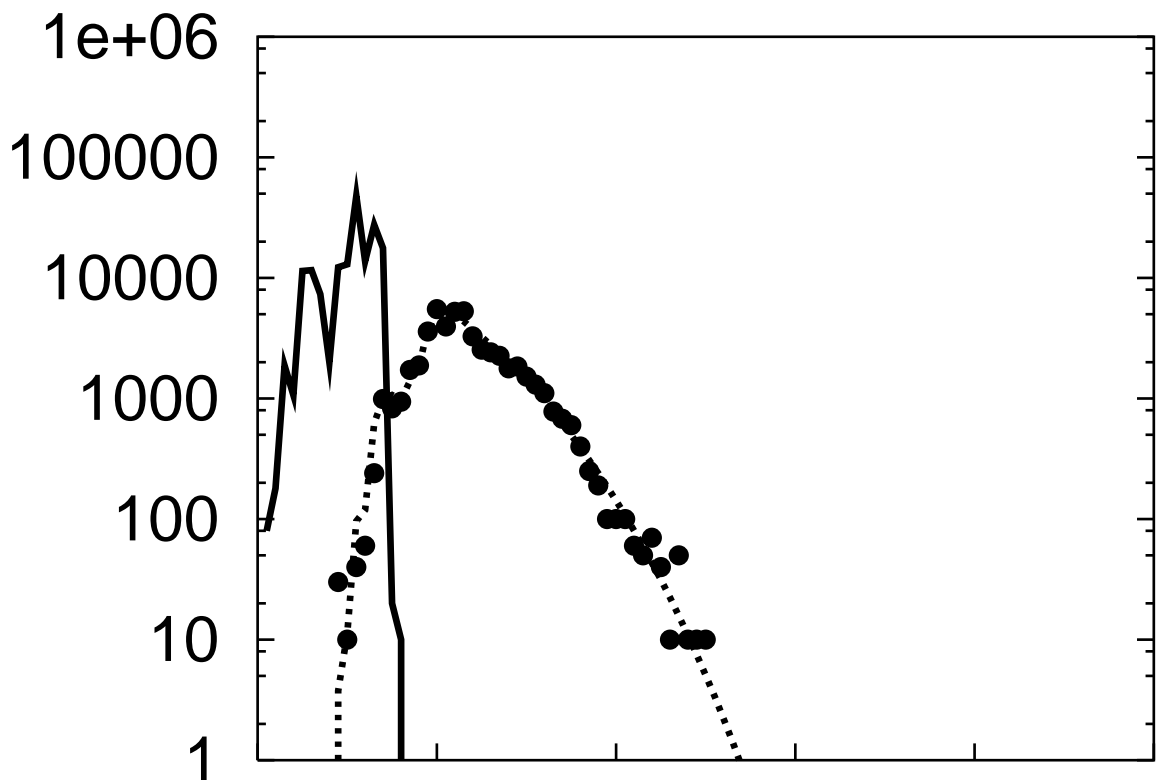
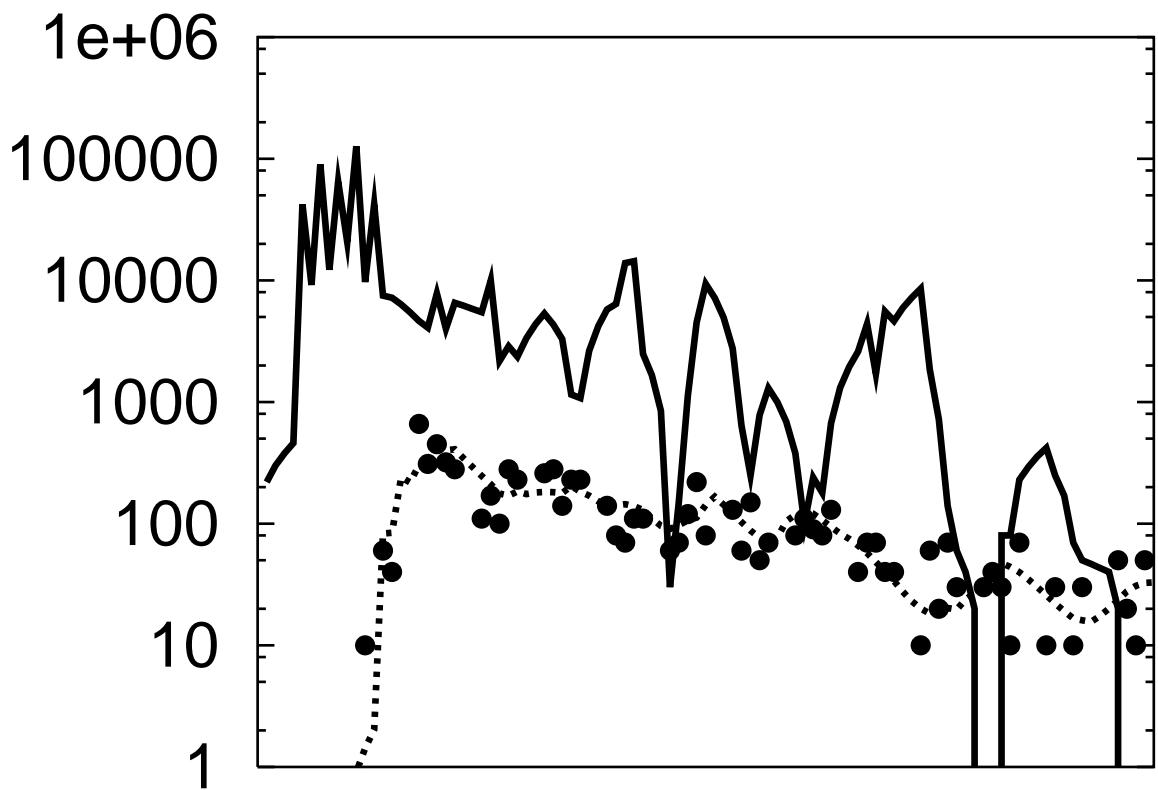
asex. parasites ———
observ. gameto. ●
expect gameto. ·····

parasites per μl blood



asex. parasites ———
observ. gameto. •
expect gameto. ·····

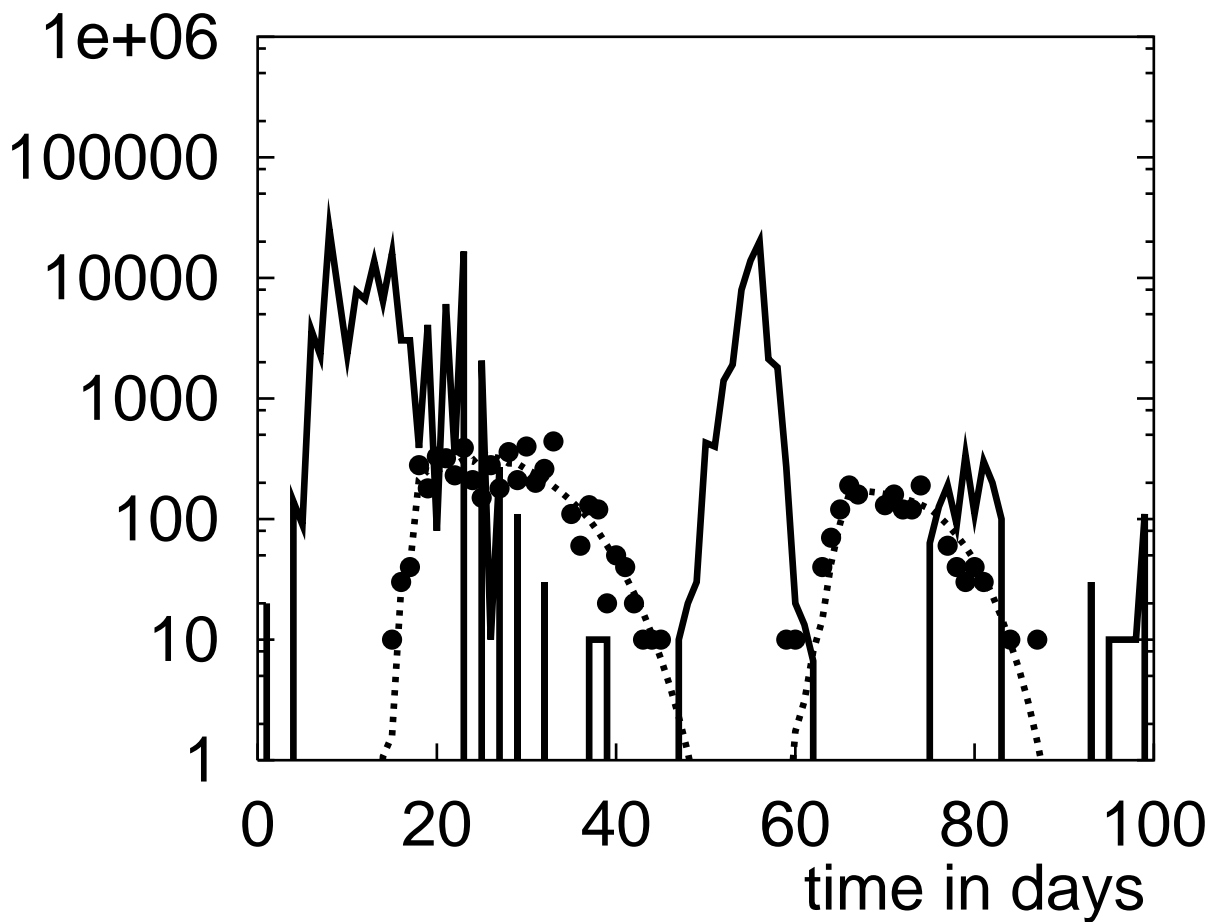
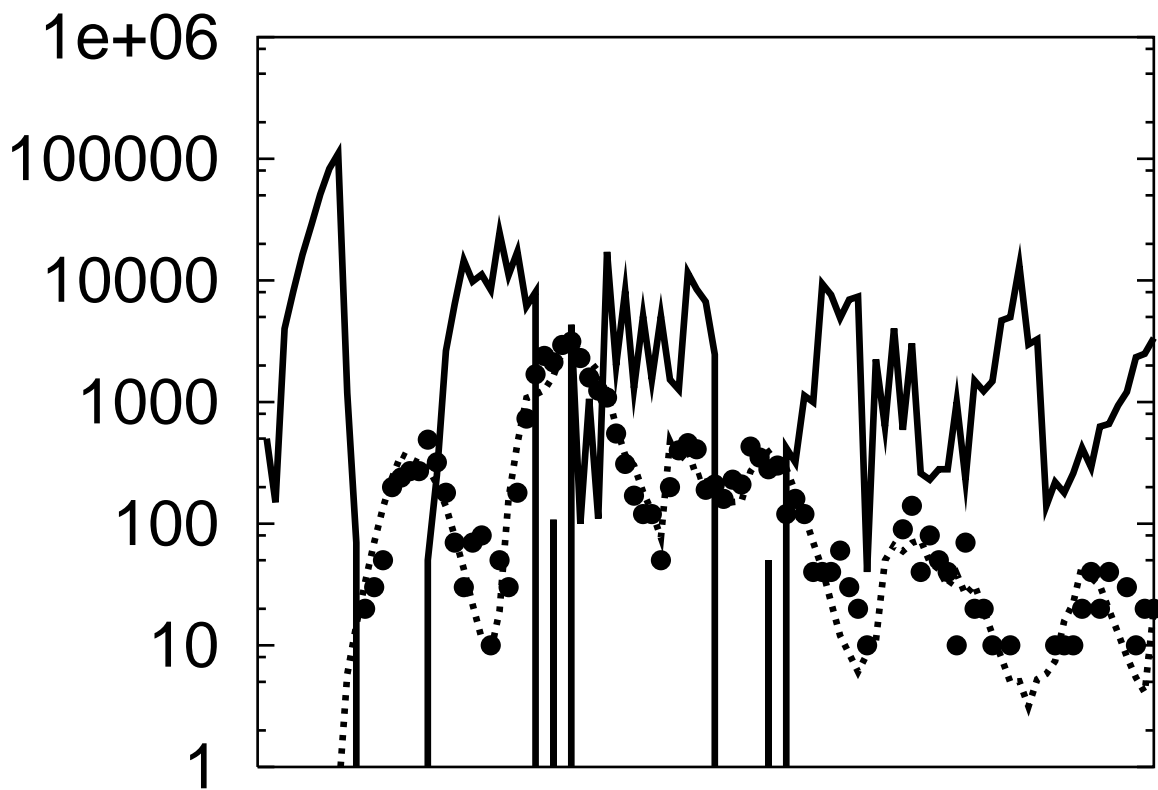
parasites per μl blood



0 20 40 60 80 100
time in days

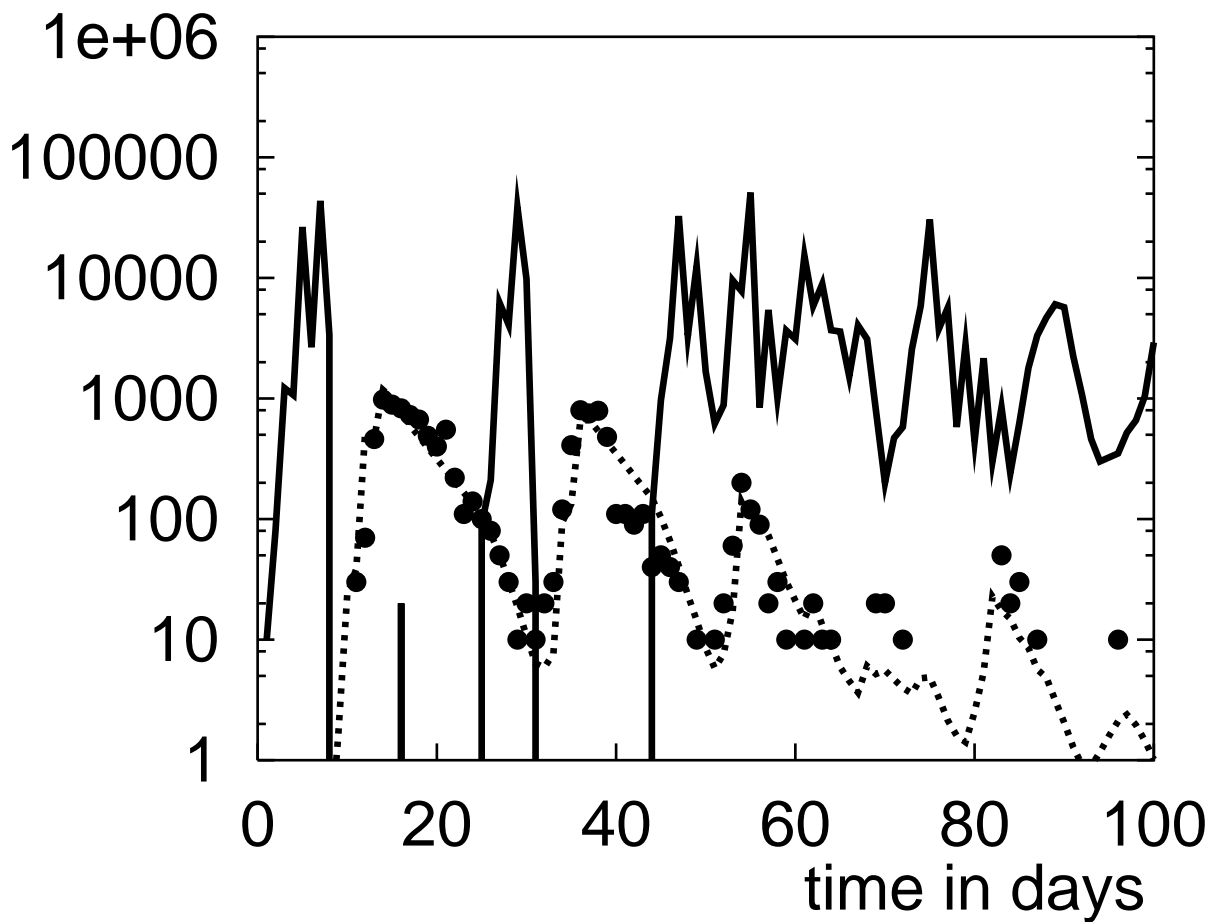
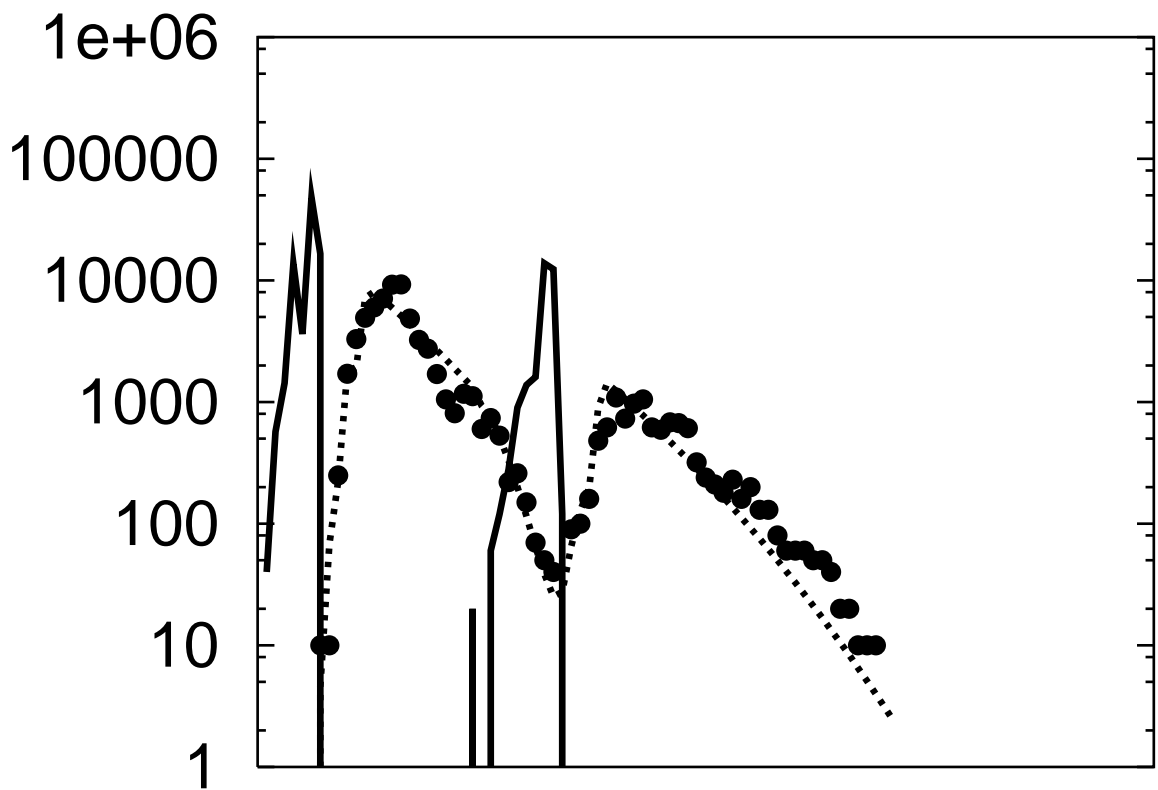
asex. parasites —
observ. gameto. •
expect gameto. ·····

parasites per μl blood



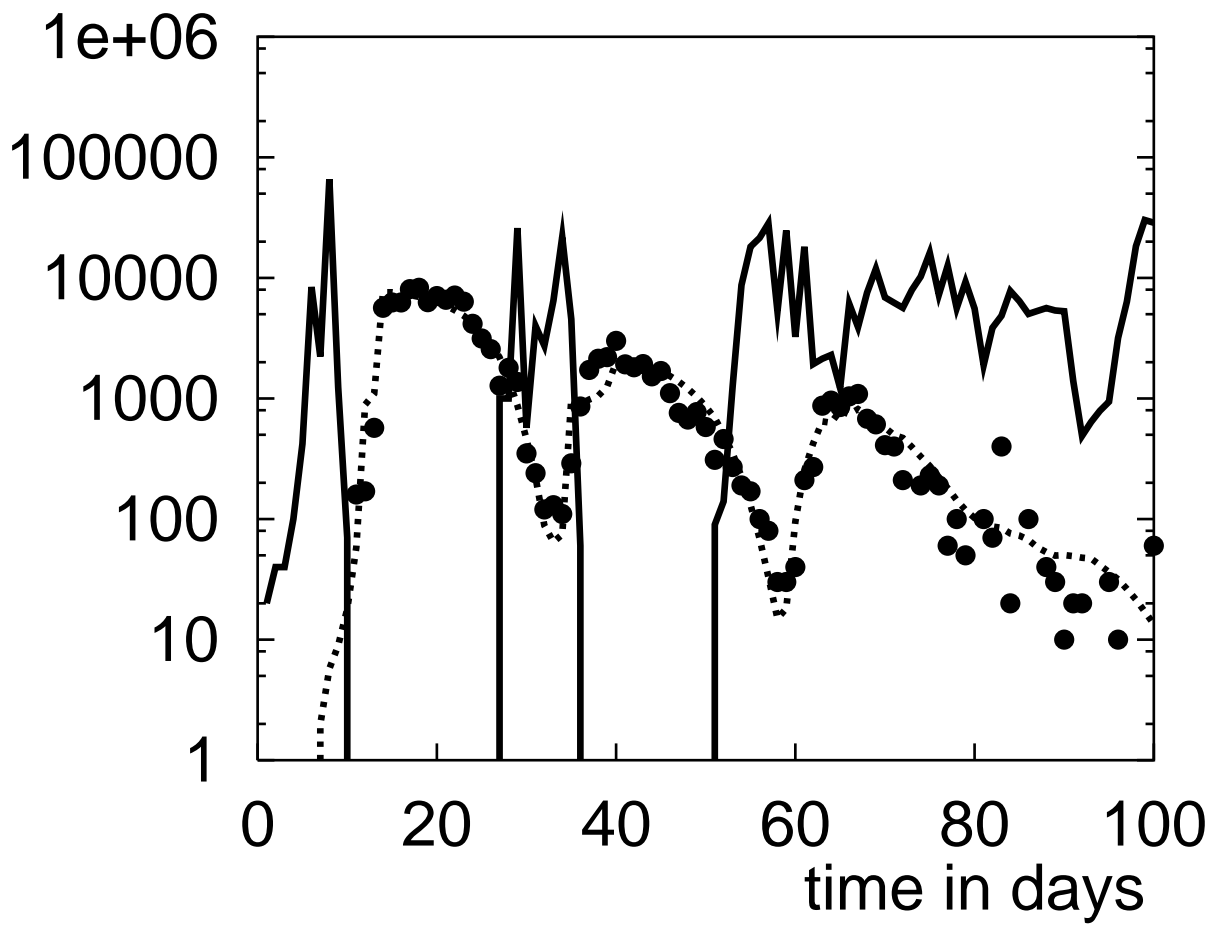
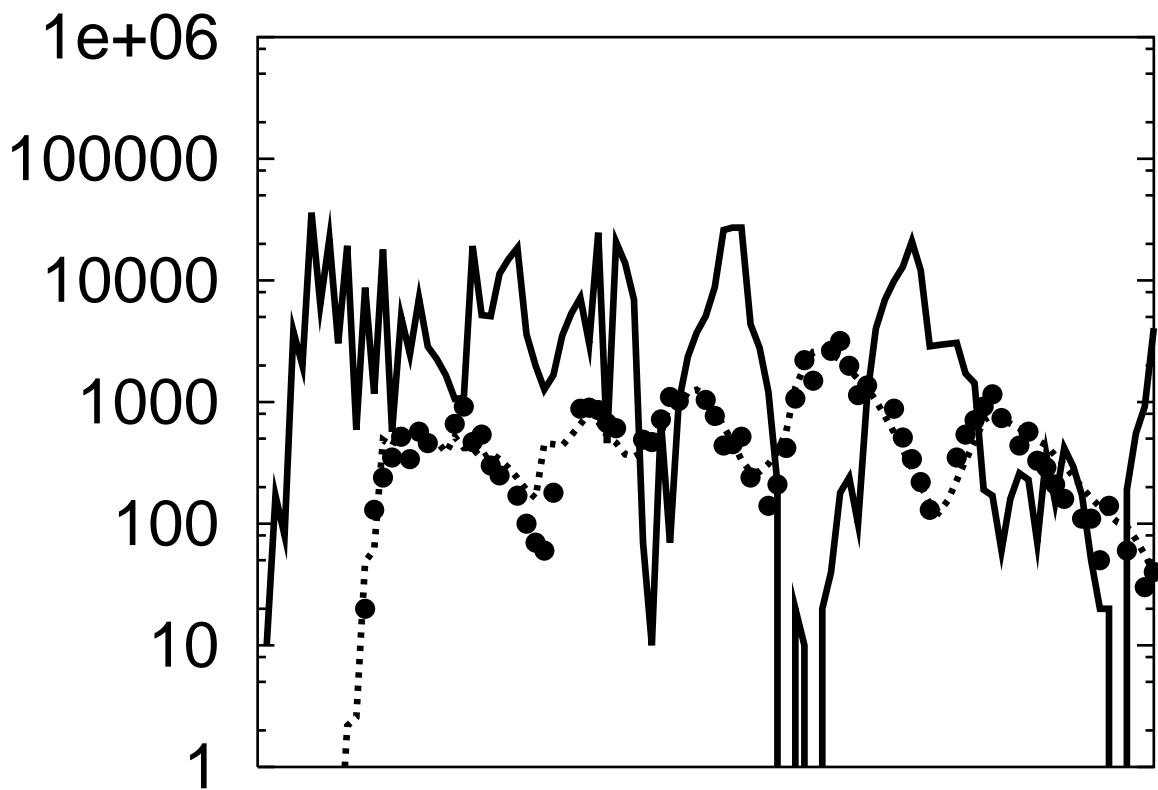
asex. parasites —
observ. gameto. •
expect gameto. ·····

parasites per μl blood



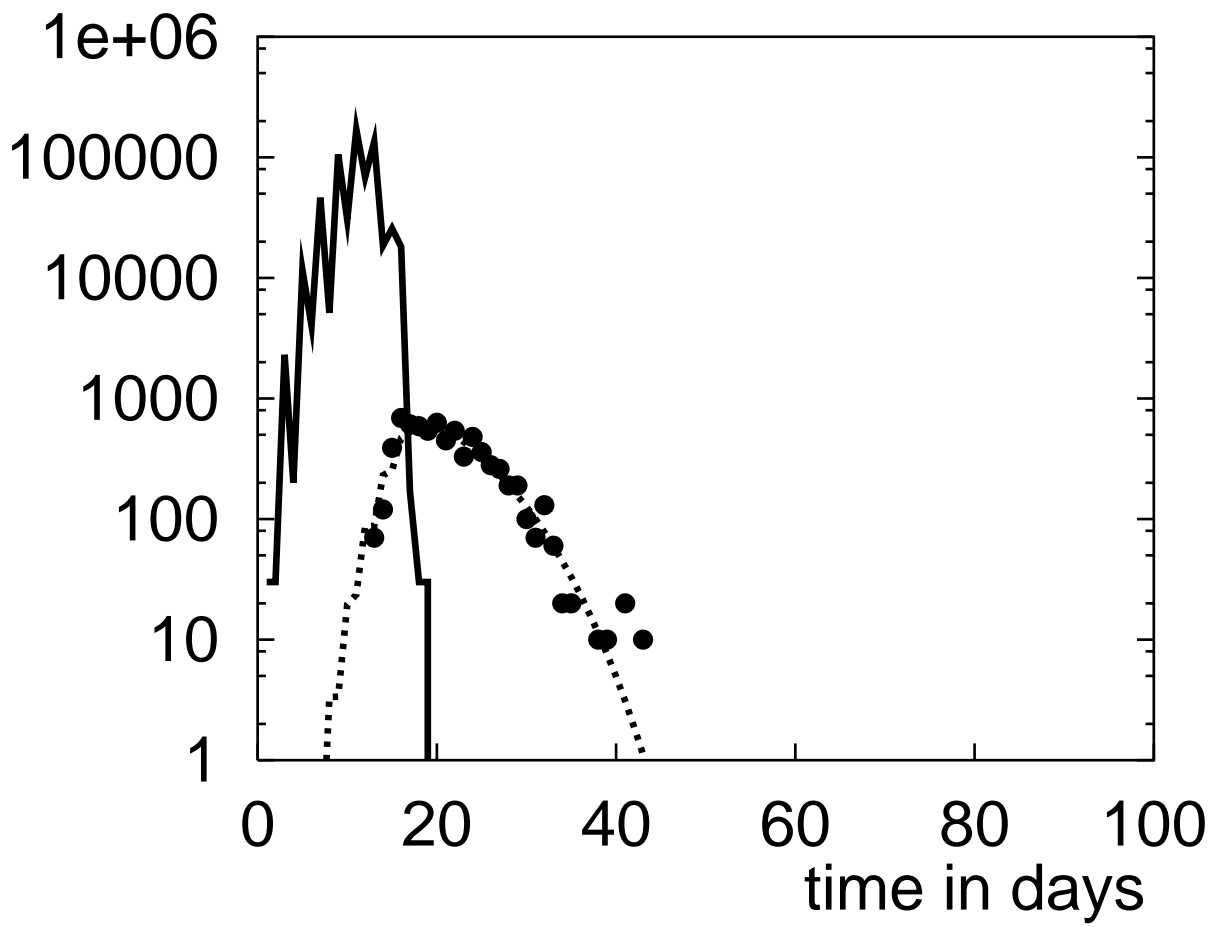
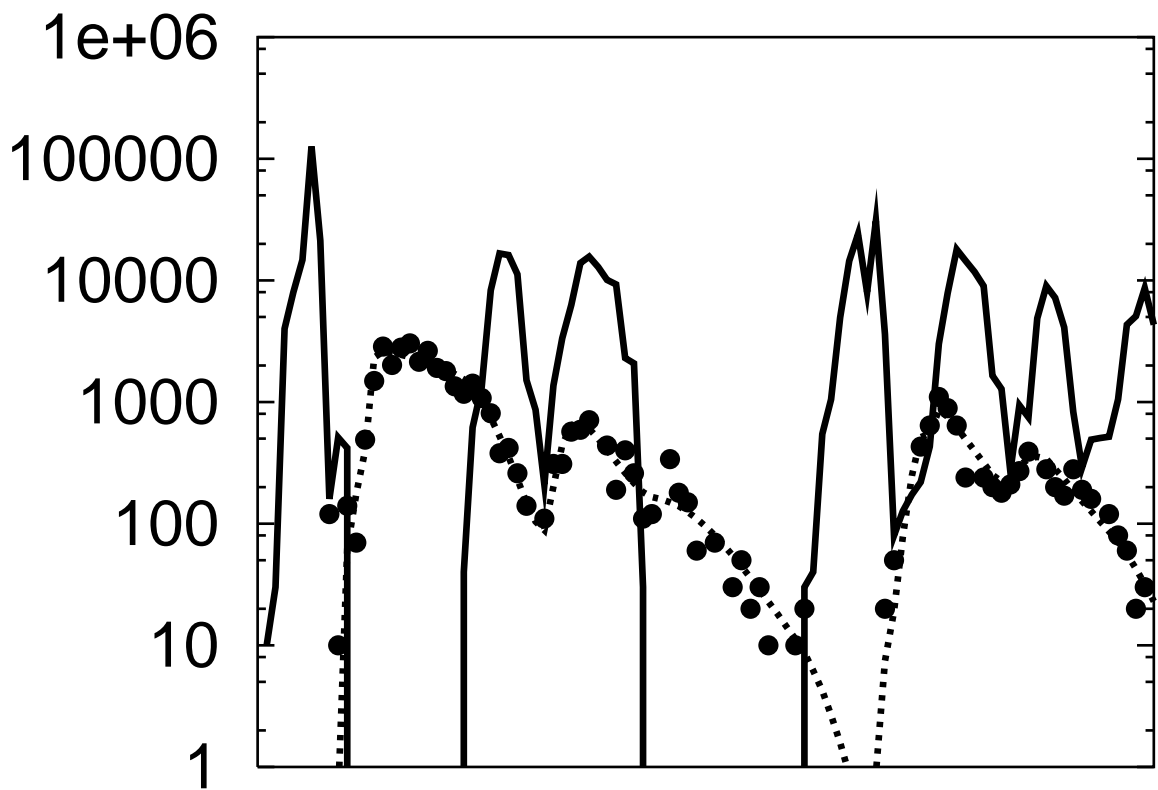
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



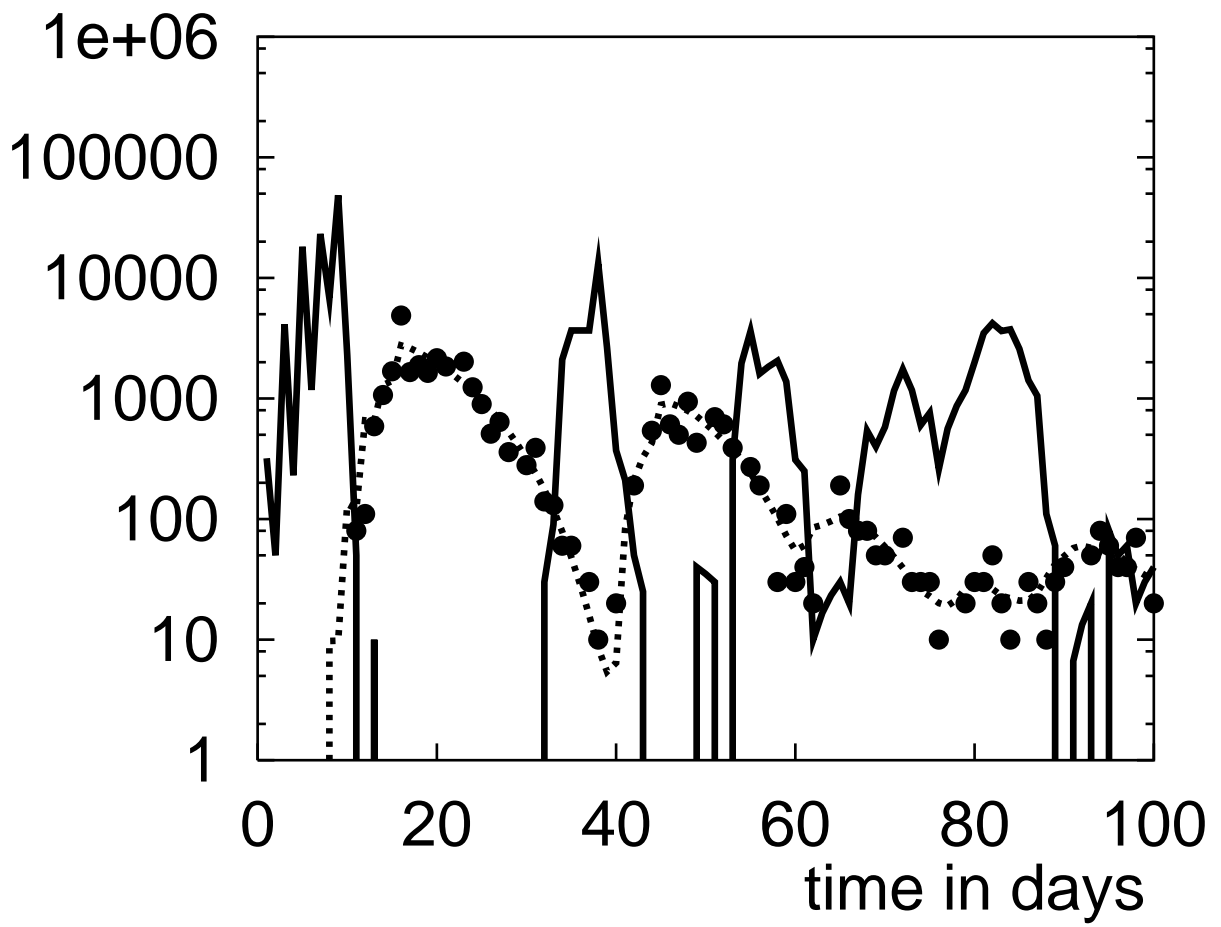
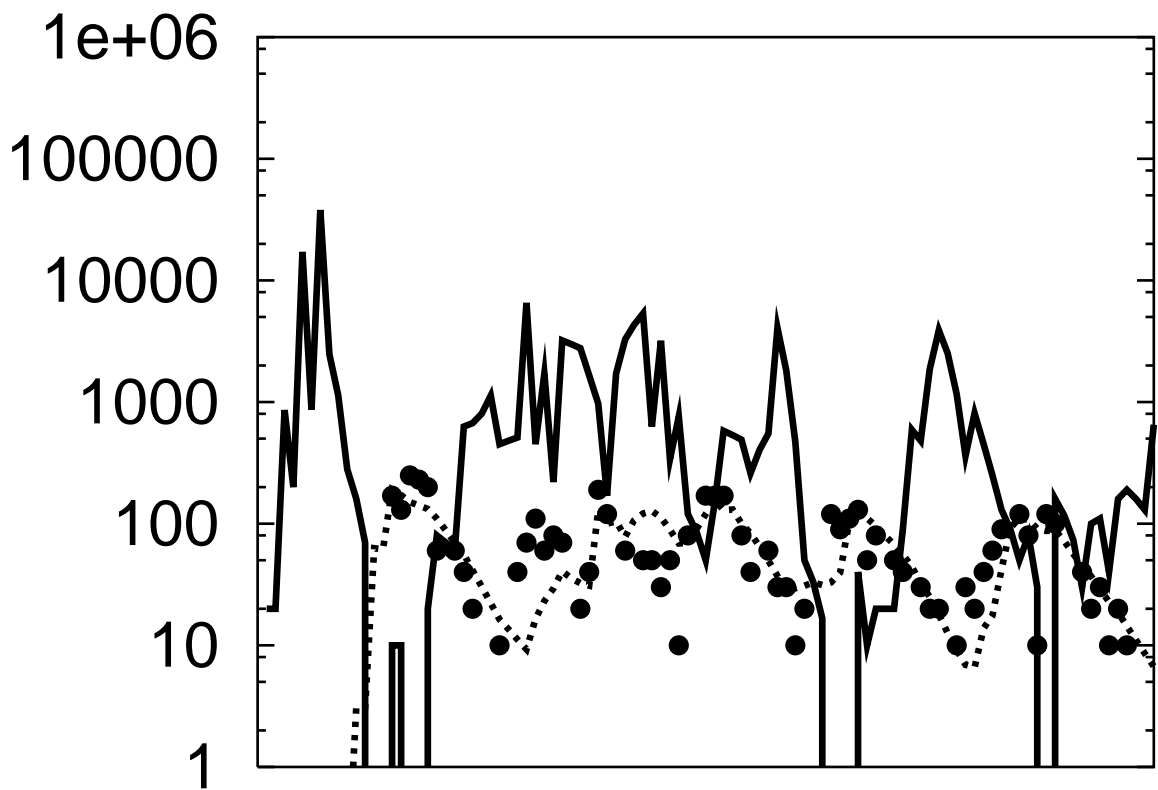
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



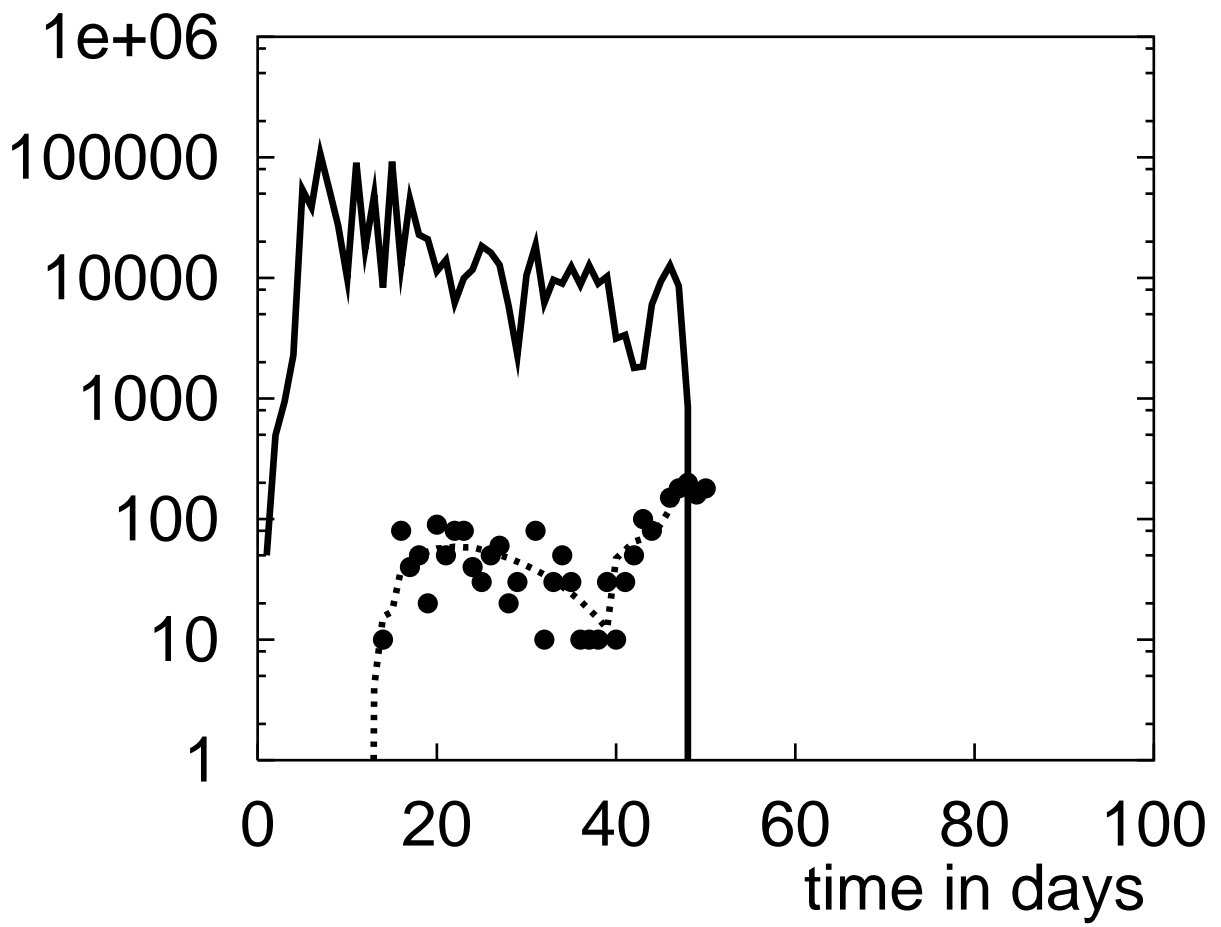
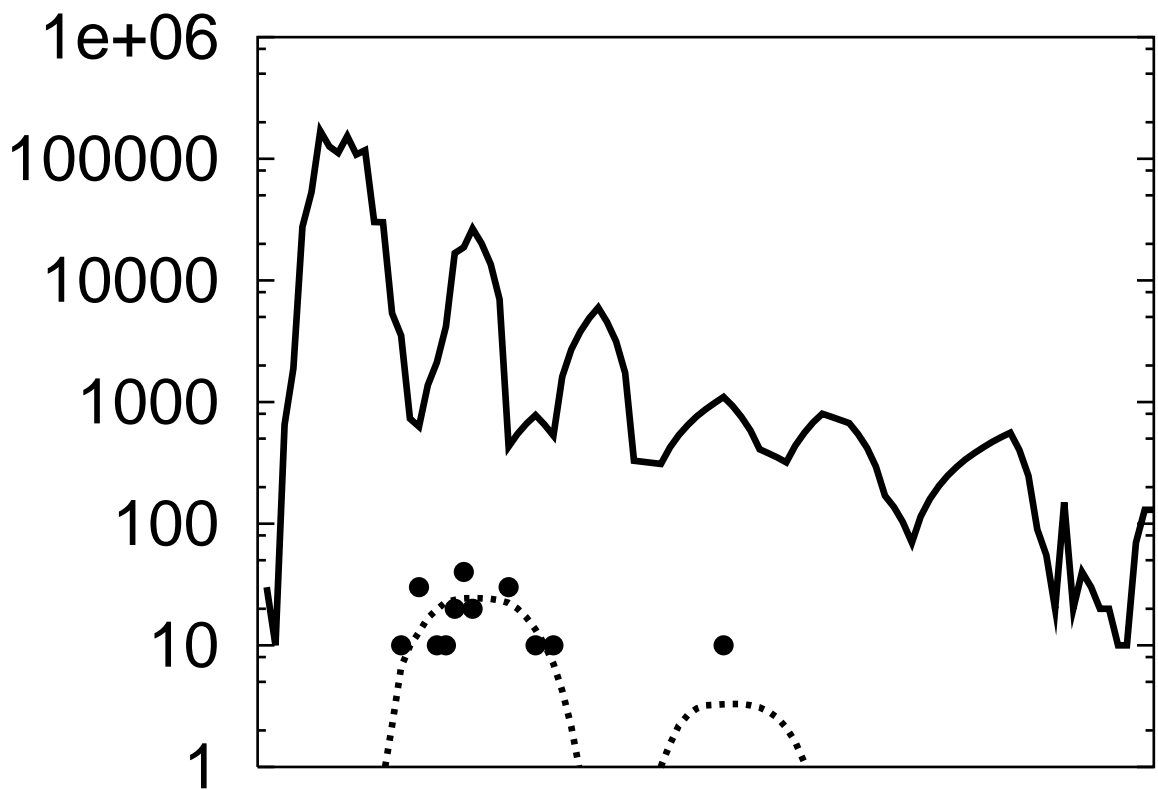
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



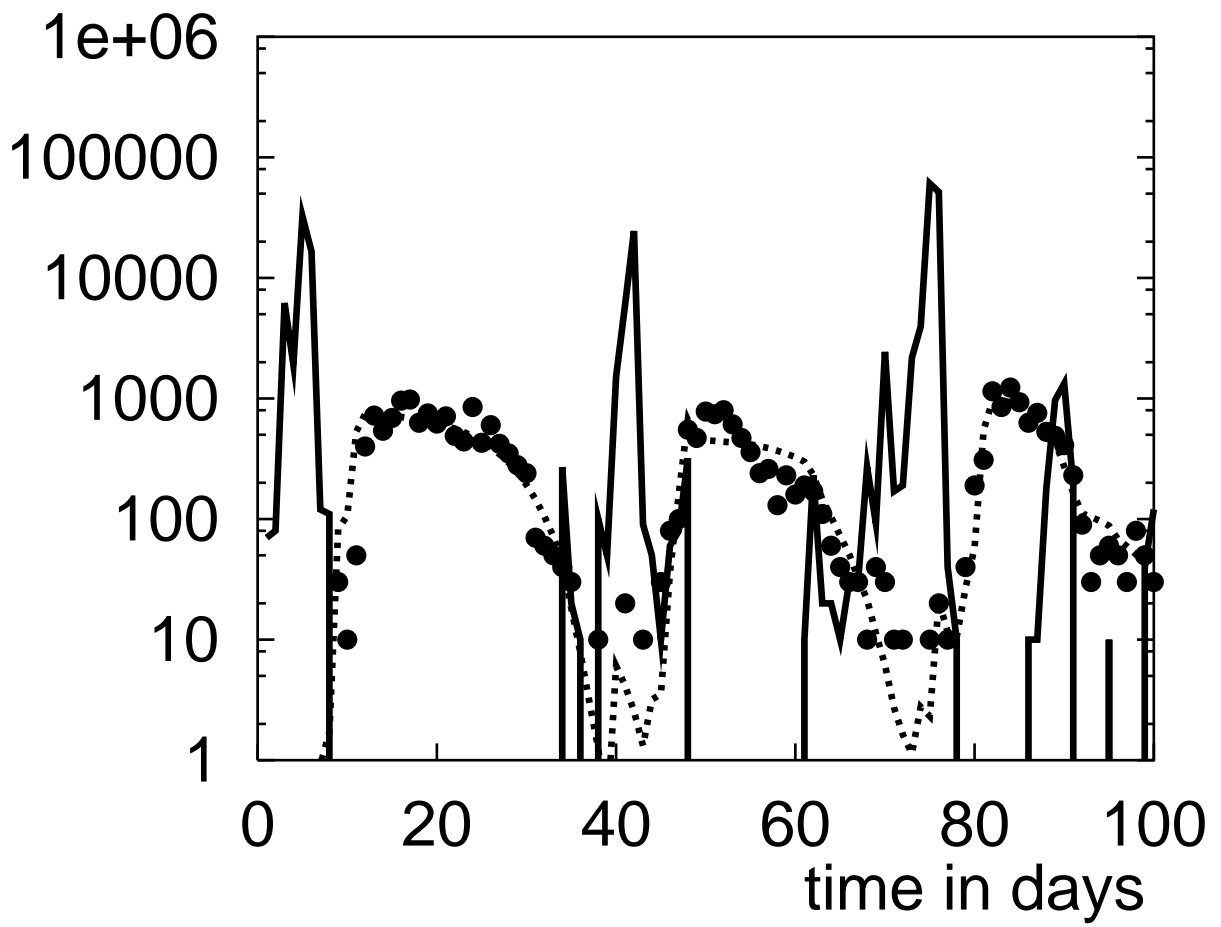
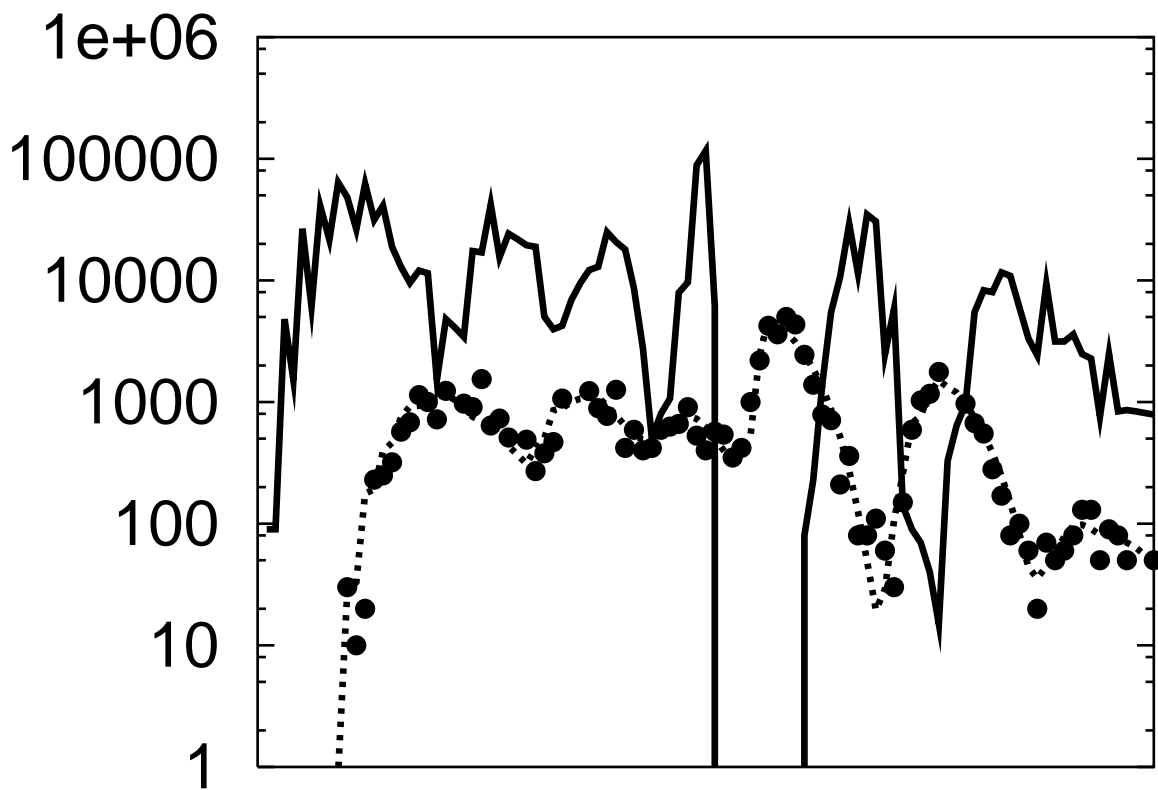
asex. parasites —————
observ. gameto. •
expect gameto. ······

parasites per μl blood



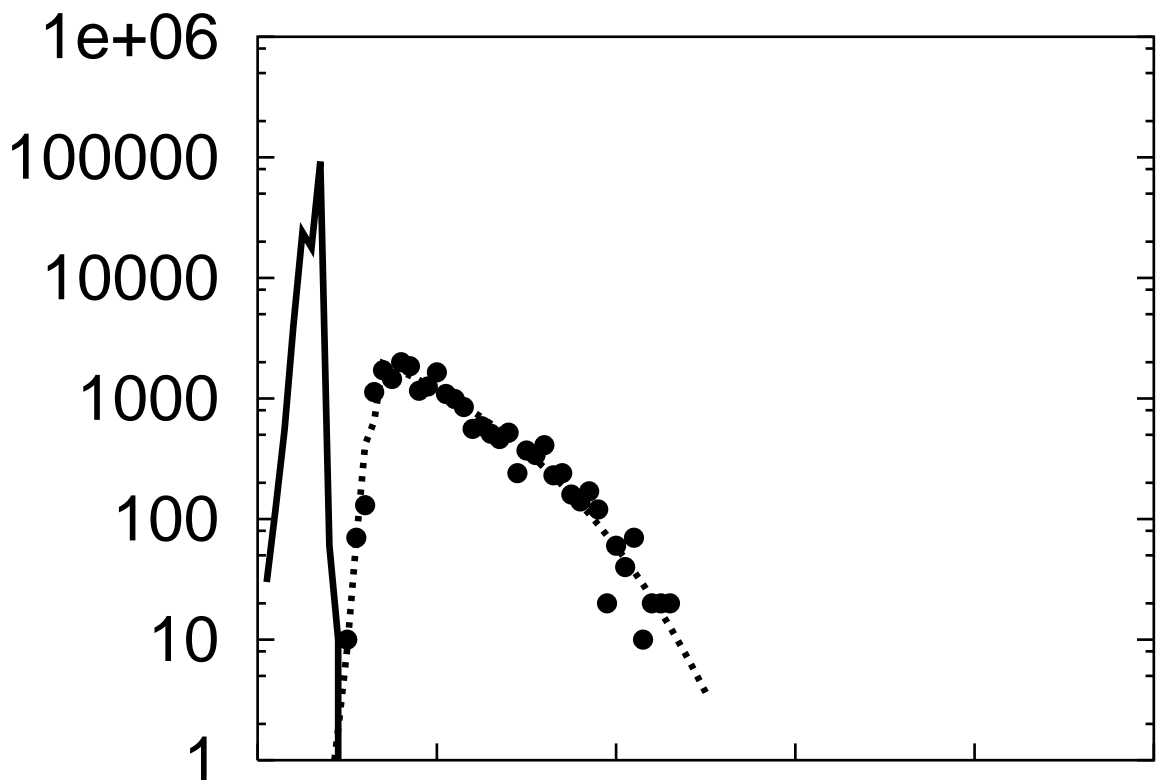
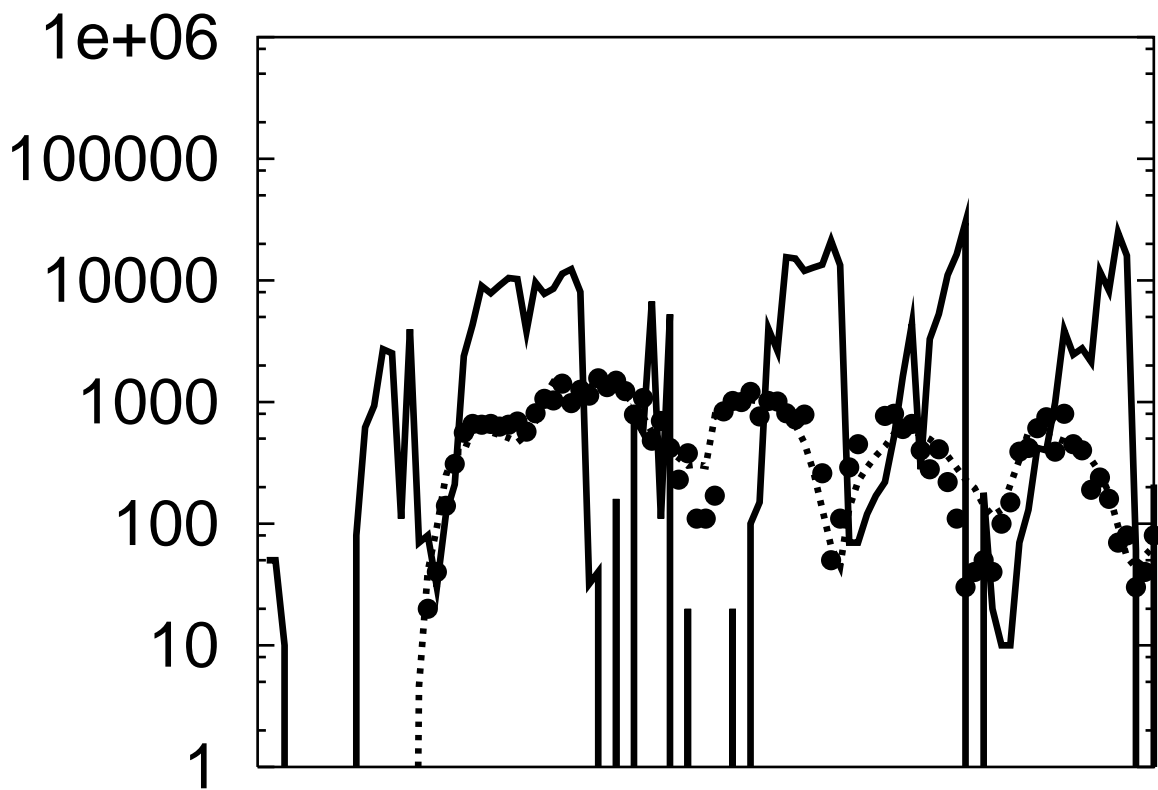
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



asex. parasites —
observ. gameto. •
expect gameto. ···

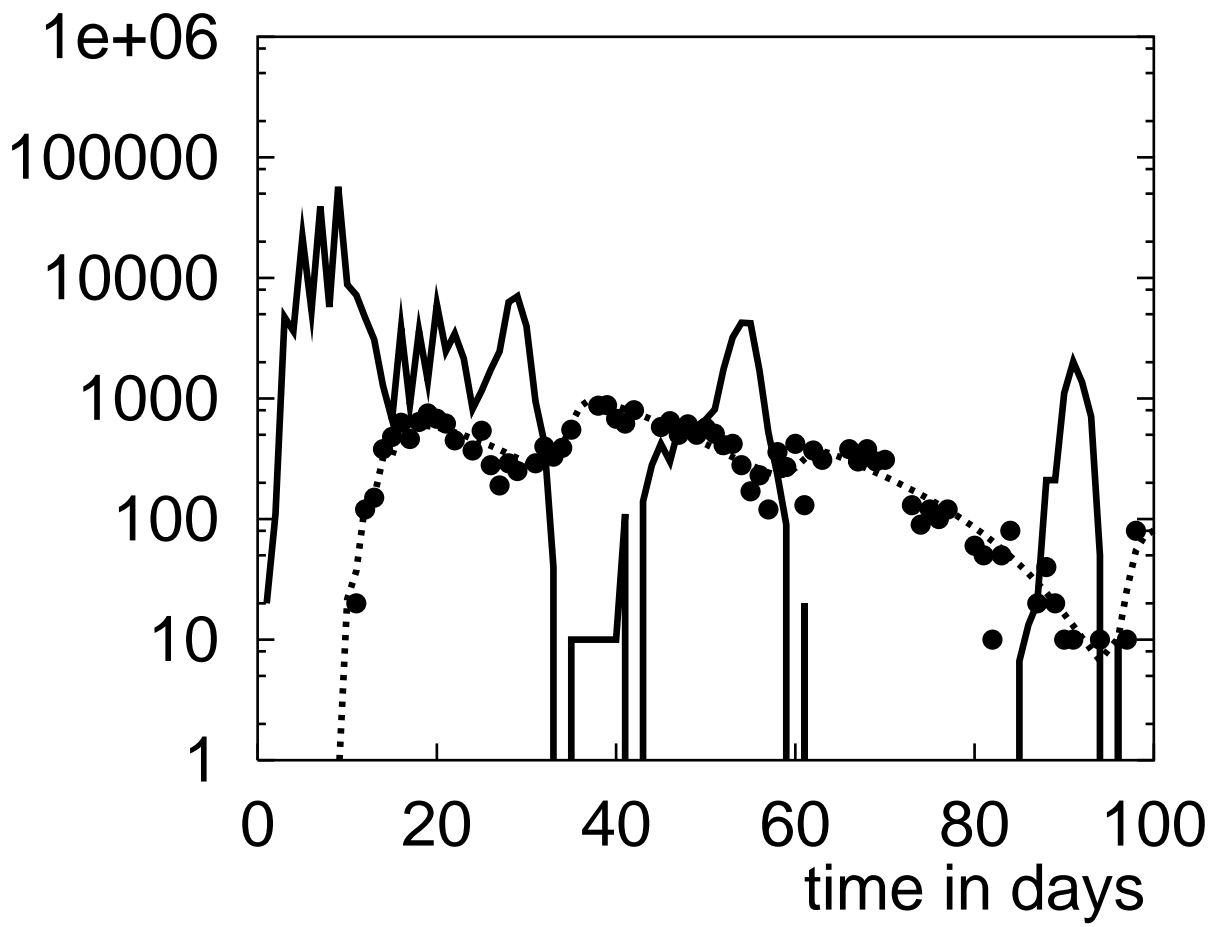
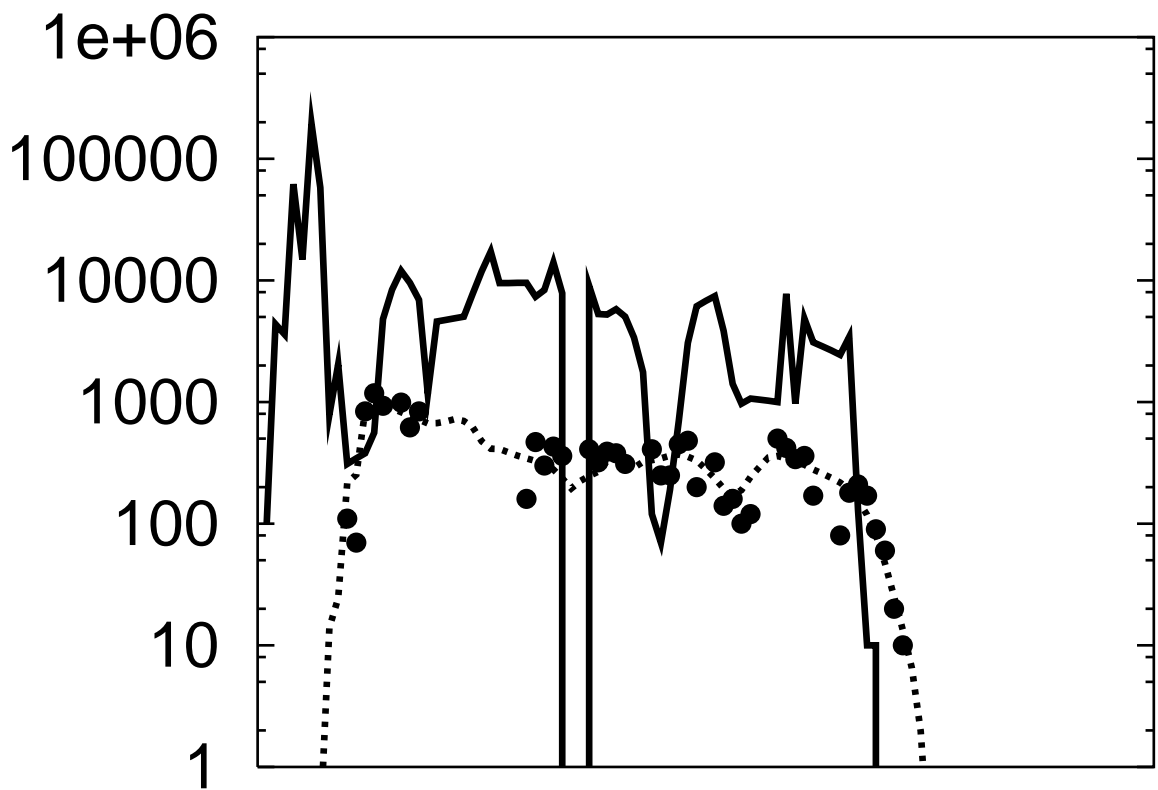
parasites per μl blood



0 20 40 60 80 100
time in days

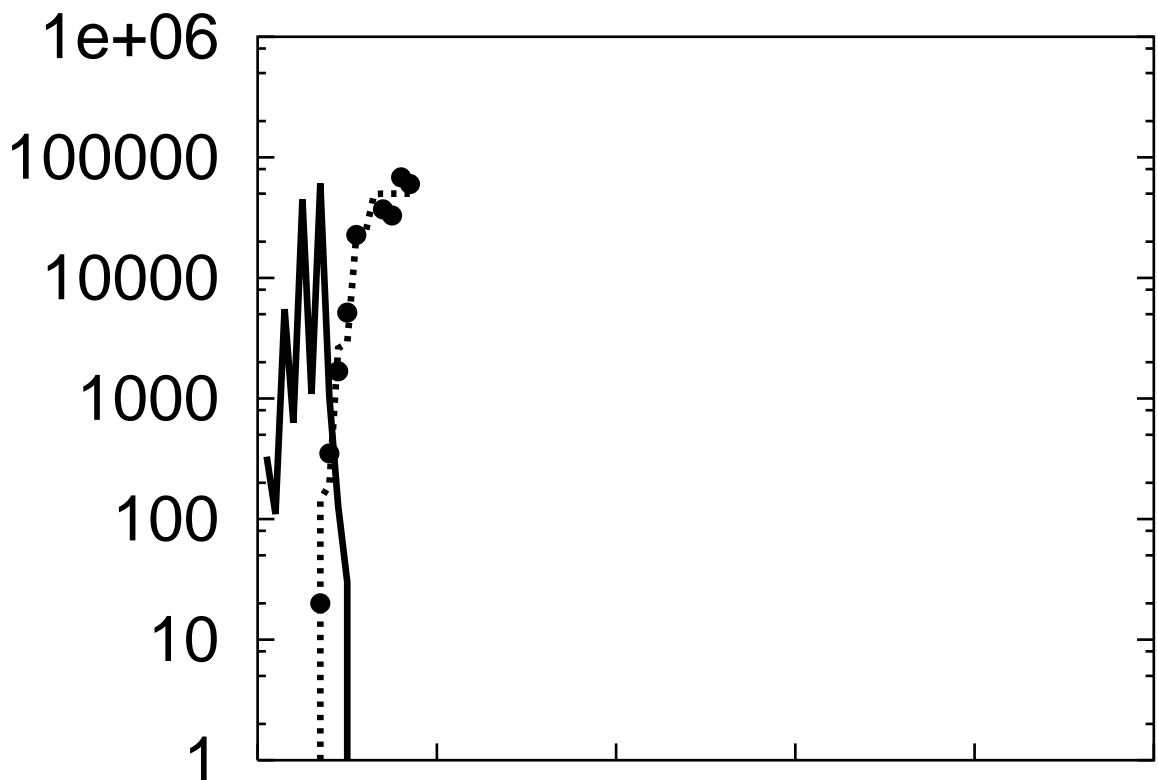
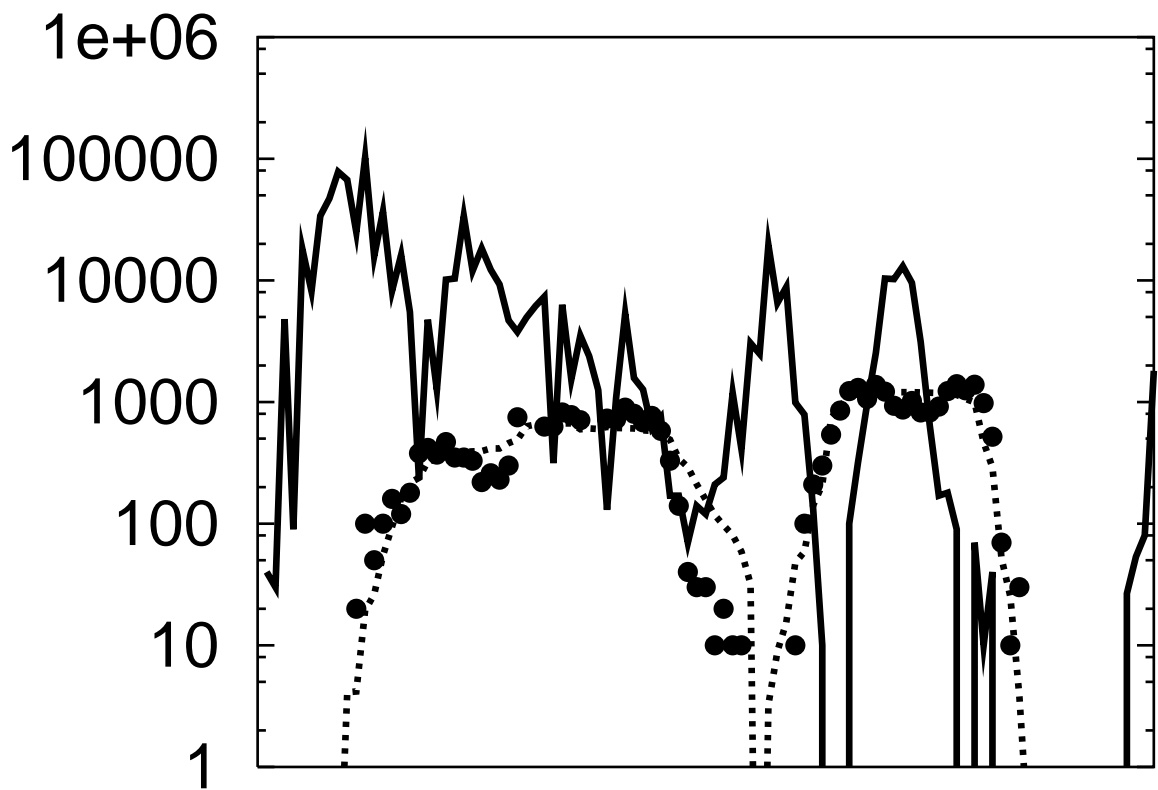
asex. parasites —
observ. gameto. •
expect gameto. ···

parasites per μl blood



asex. parasites ———
observ. gameto. •
expect gameto. ·····

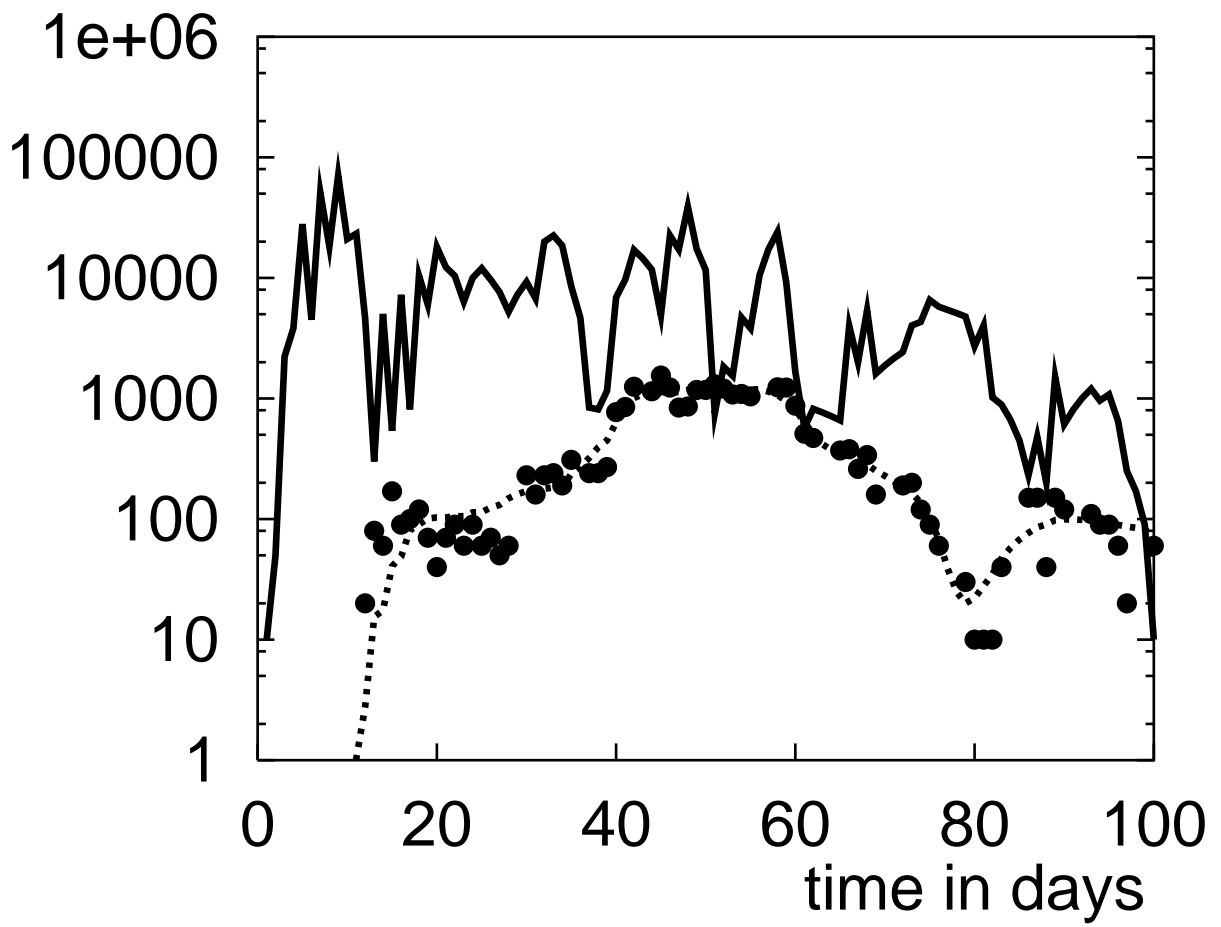
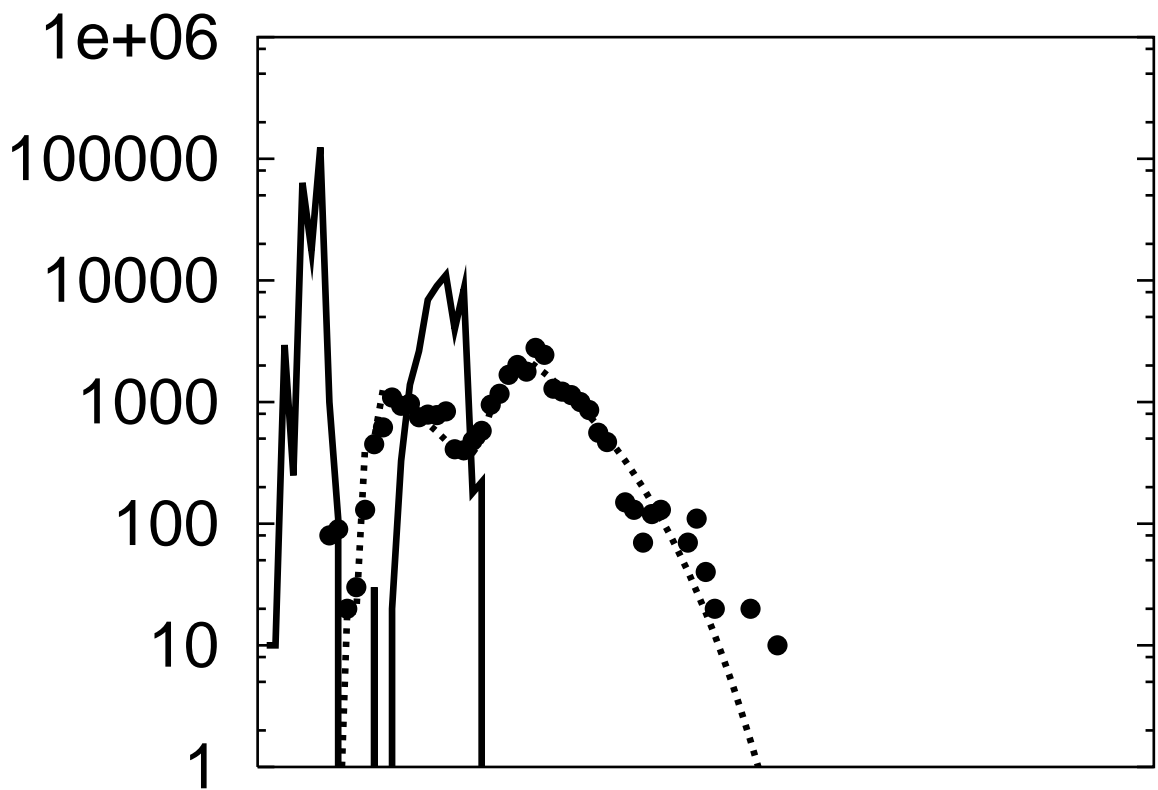
parasites per μl blood



0 20 40 60 80 100
time in days

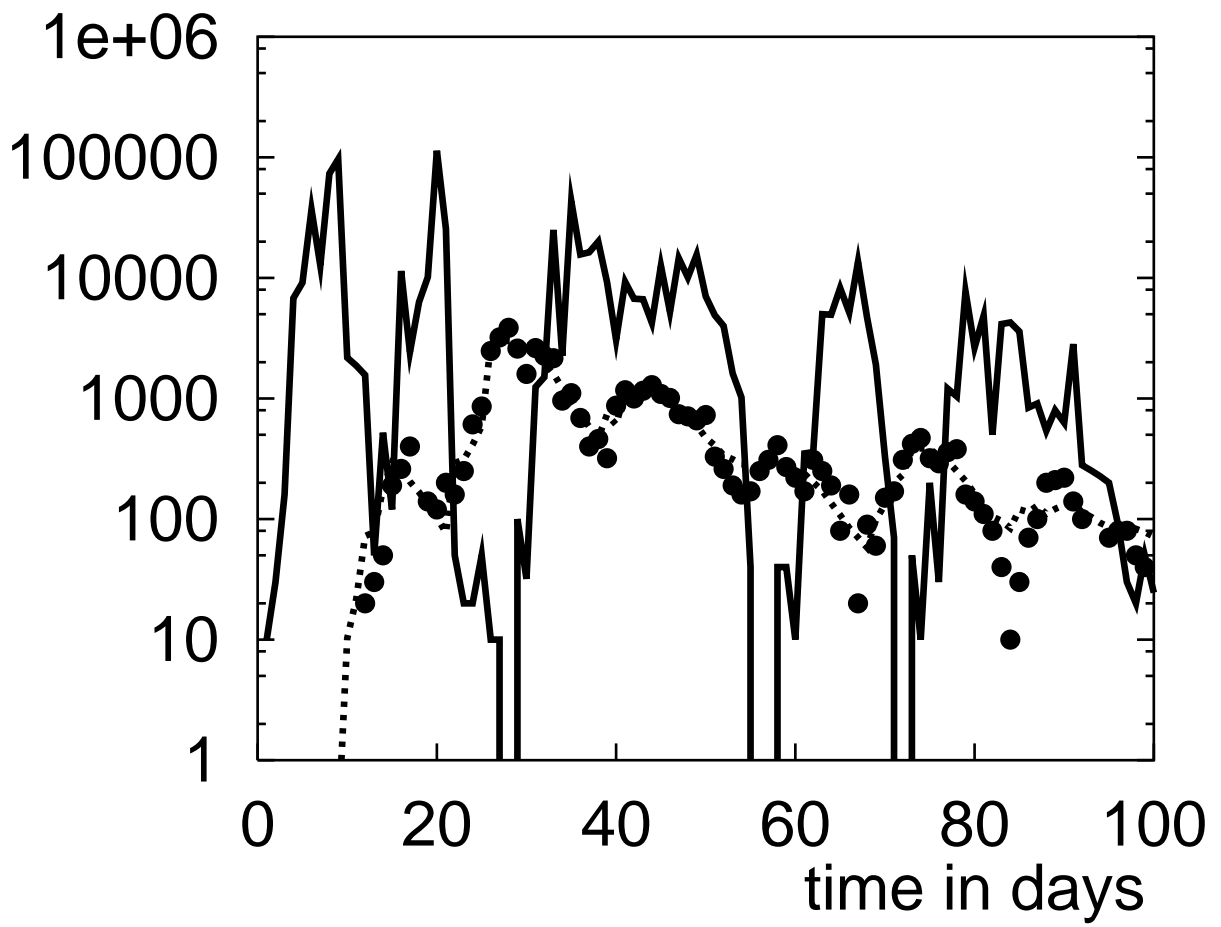
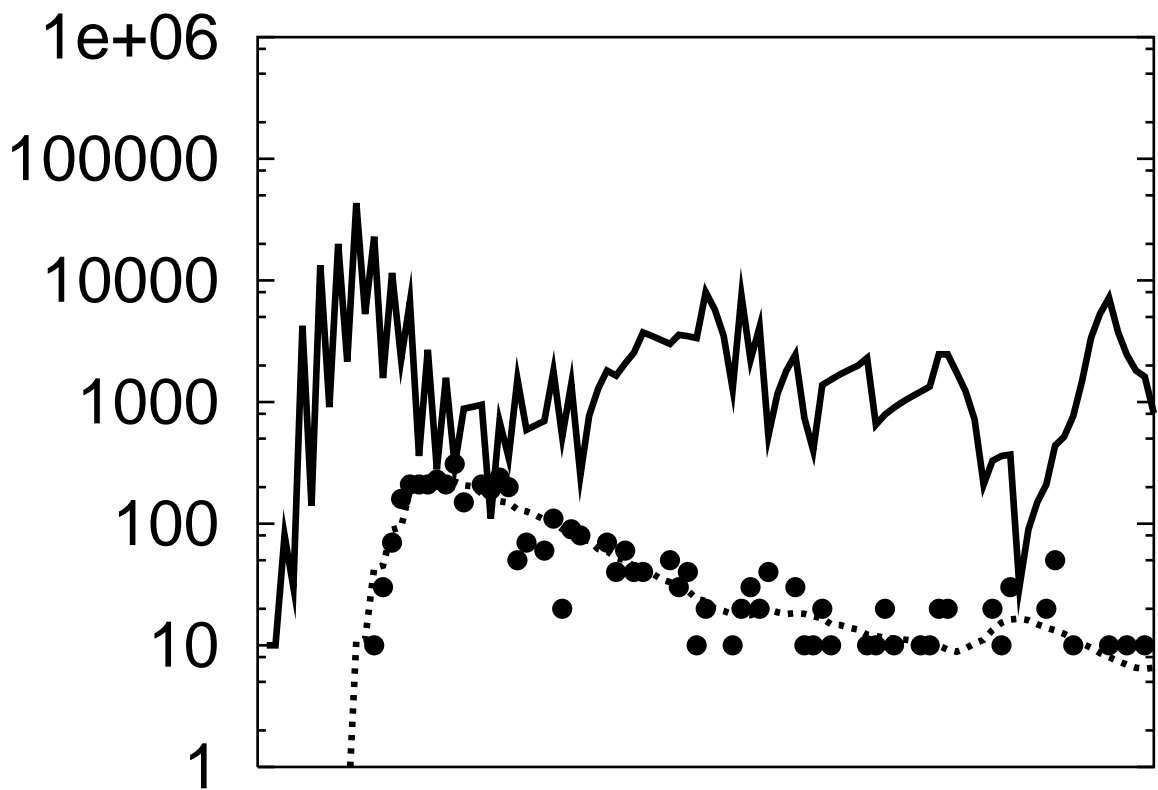
asex. parasites —
observ. gameto. •
expect gameto. ···

parasites per μl blood



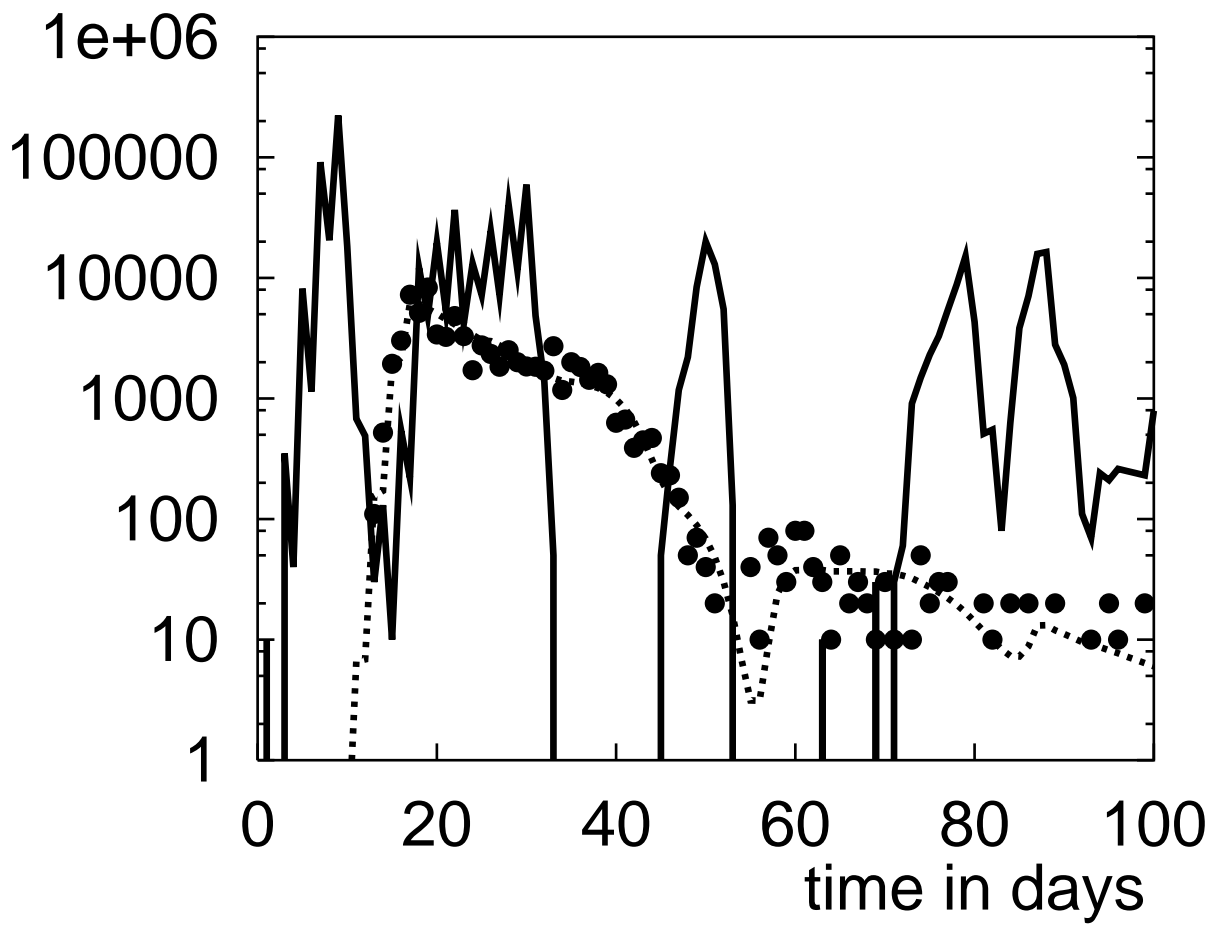
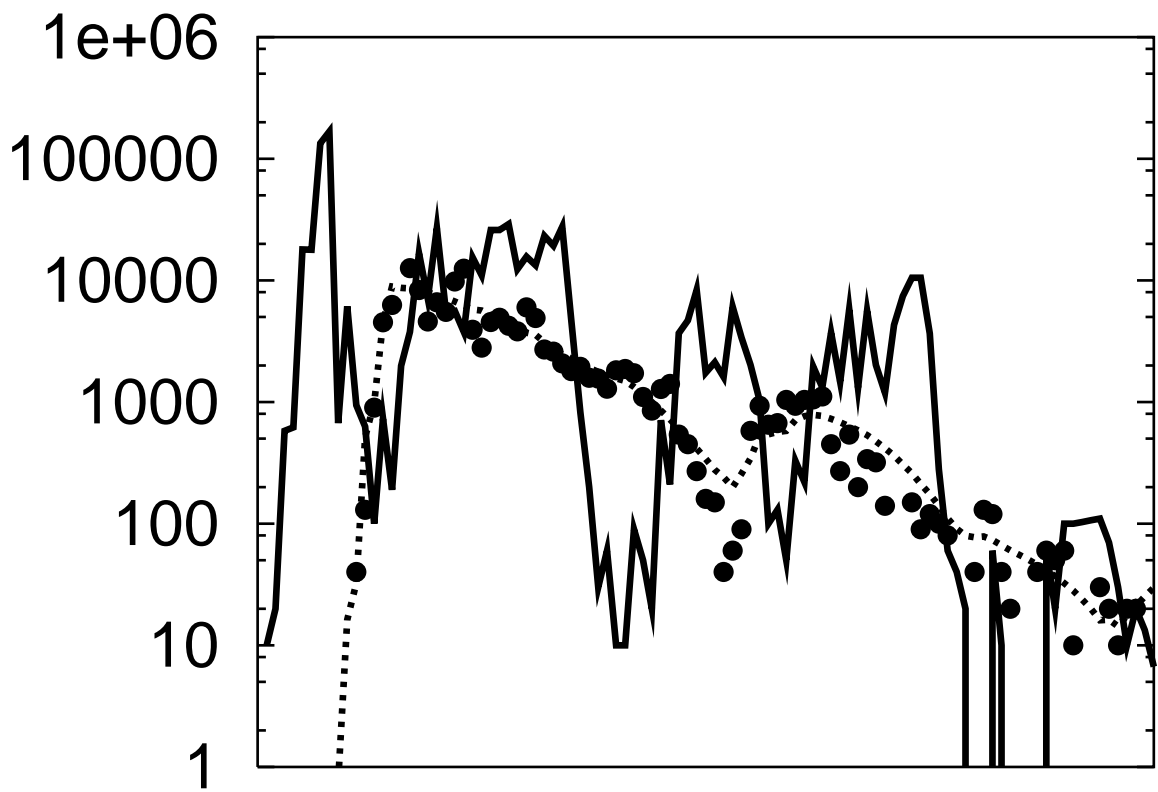
asex. parasites —
observ. gameto. •
expect gameto. ···

parasites per μl blood



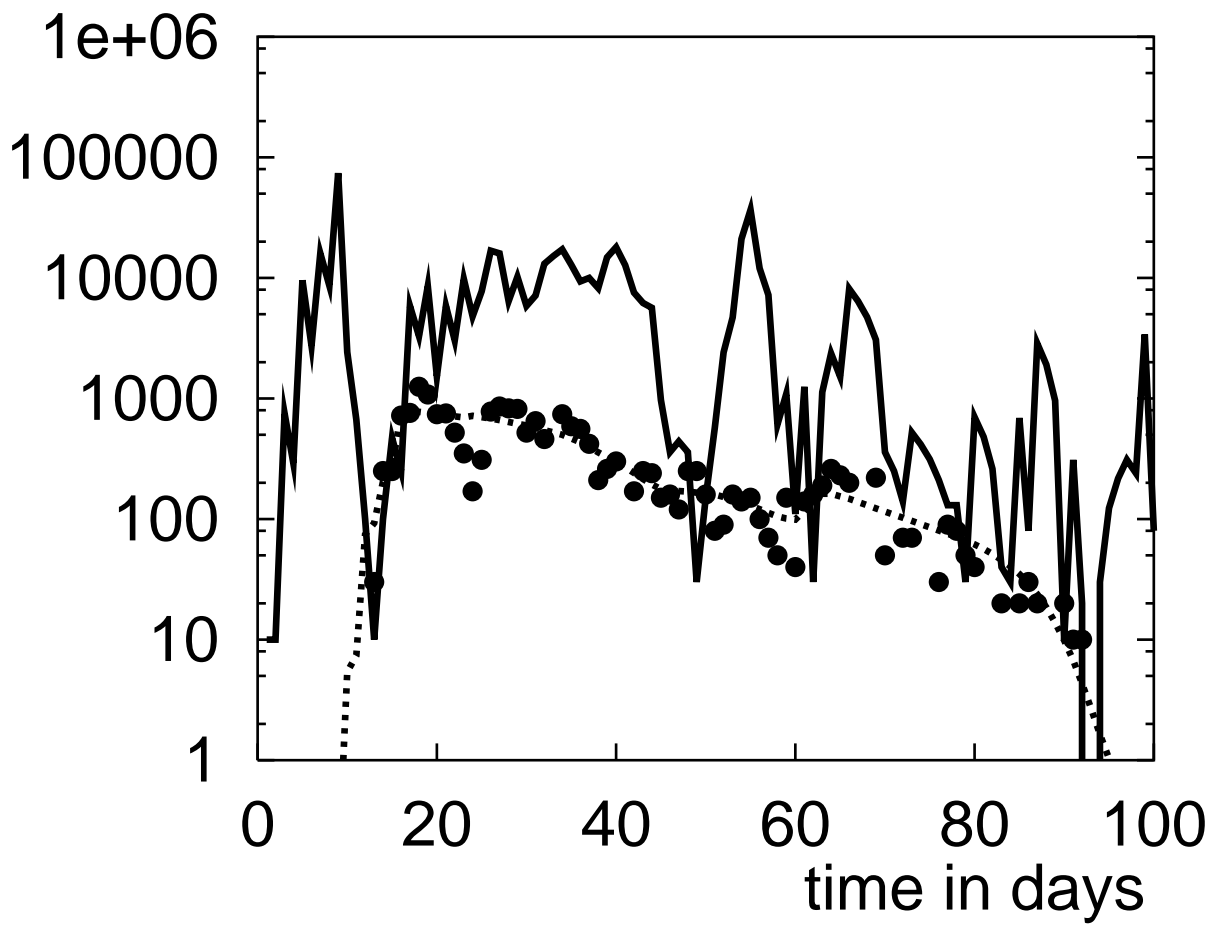
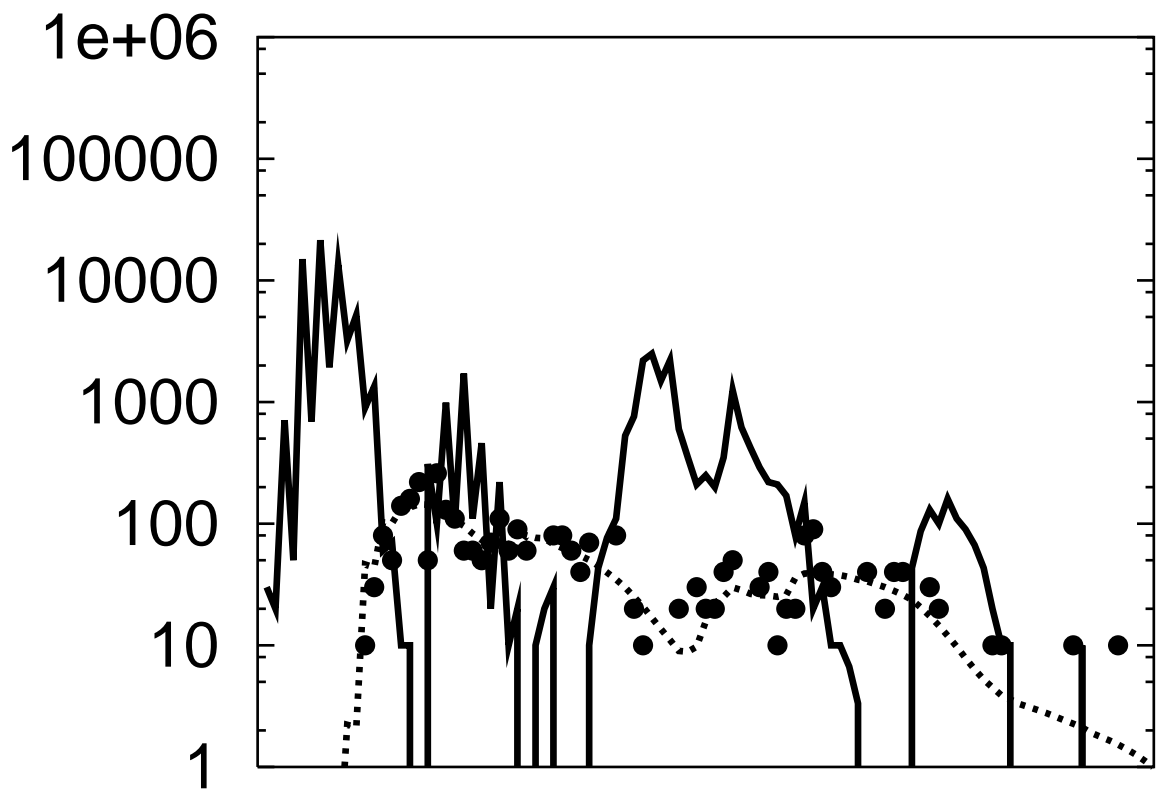
asex. parasites —
observ. gameto. •
expect gameto. ·····

parasites per μl blood



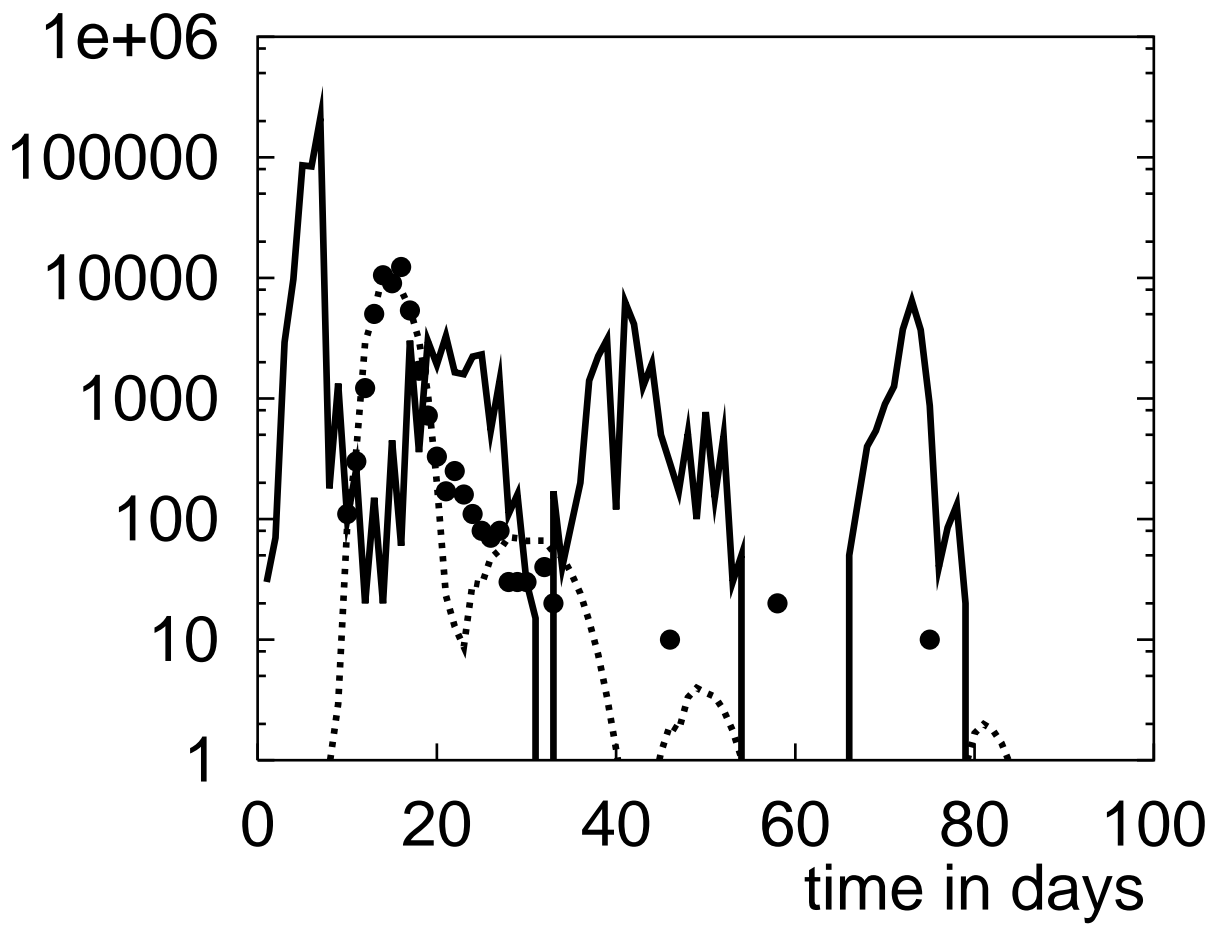
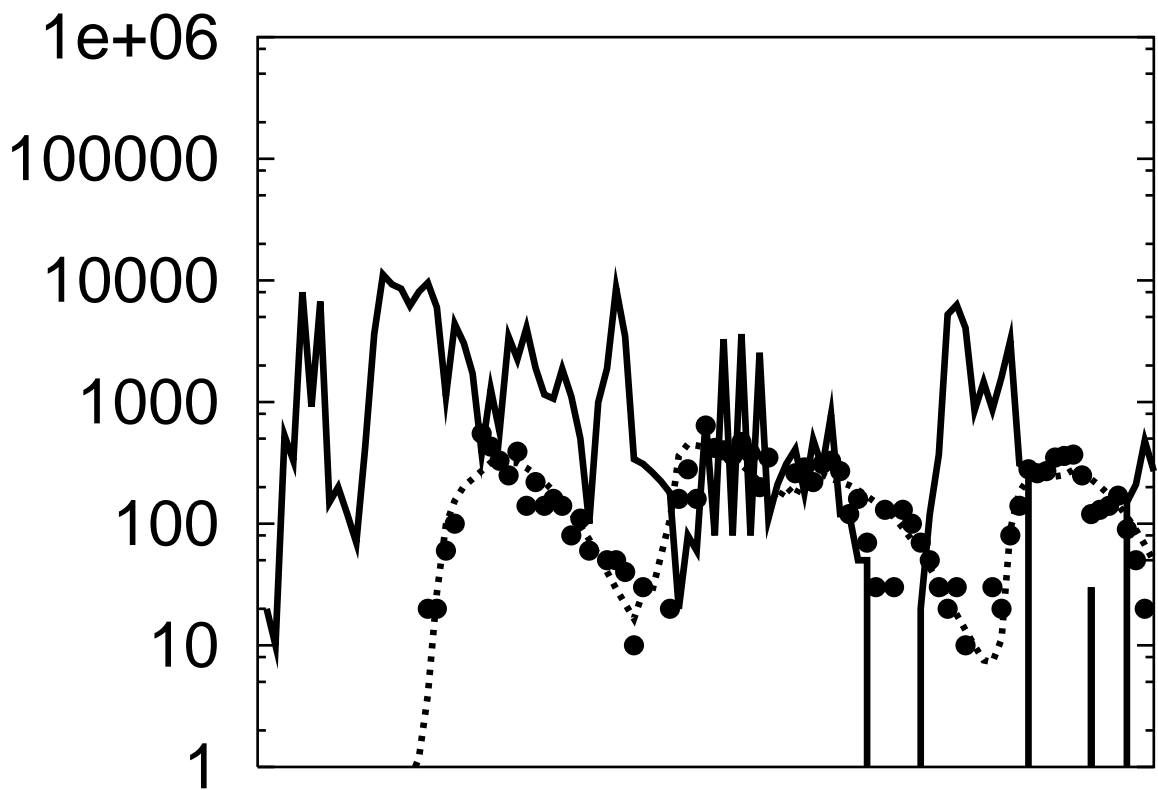
asex. parasites —
observ. gameto. •
expect gameto. ·····

parasites per μl blood



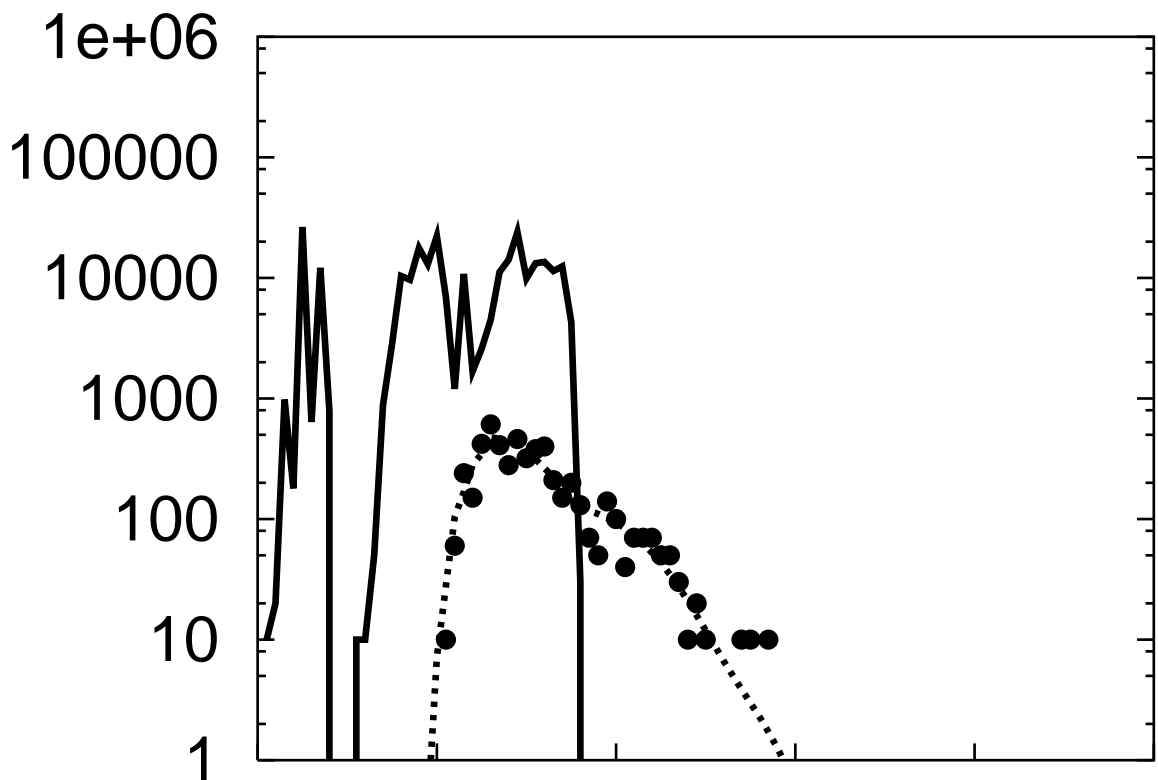
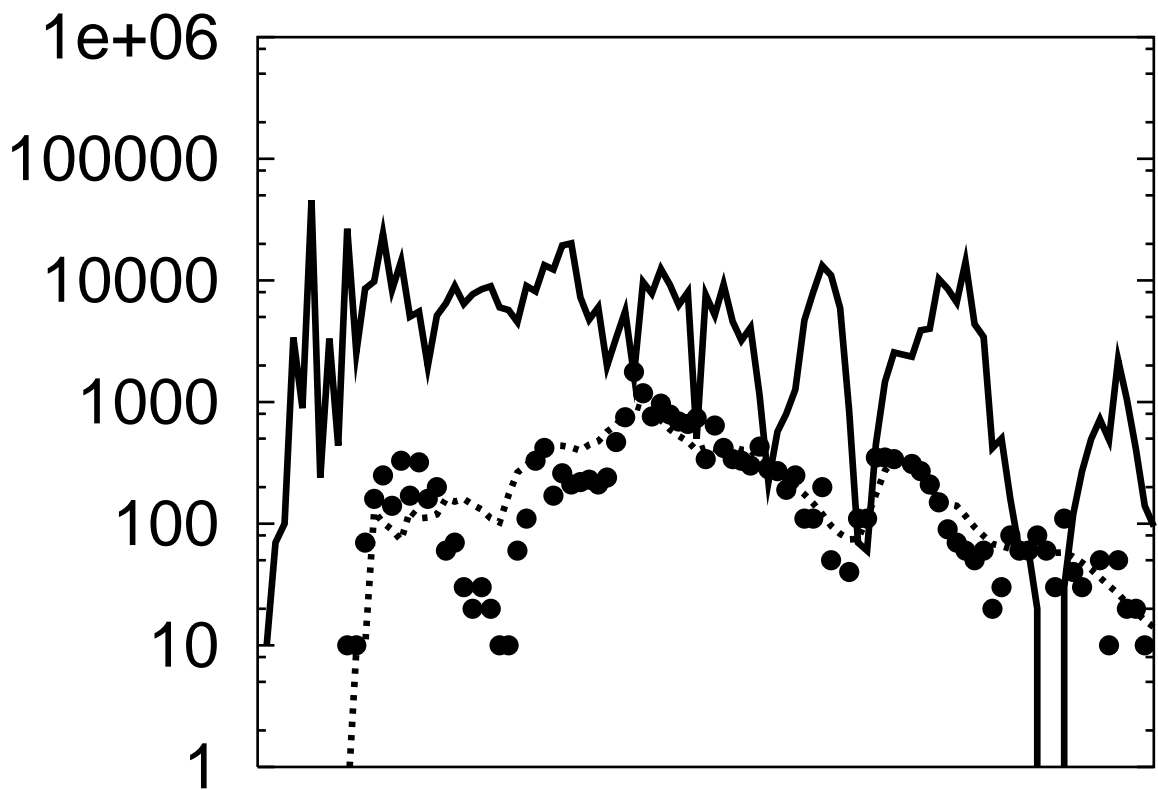
asex. parasites —
observ. gameto. •
expect gameto. ·····

parasites per μl blood



asex. parasites ———
observ. gameto. ●
expect gameto. ·····

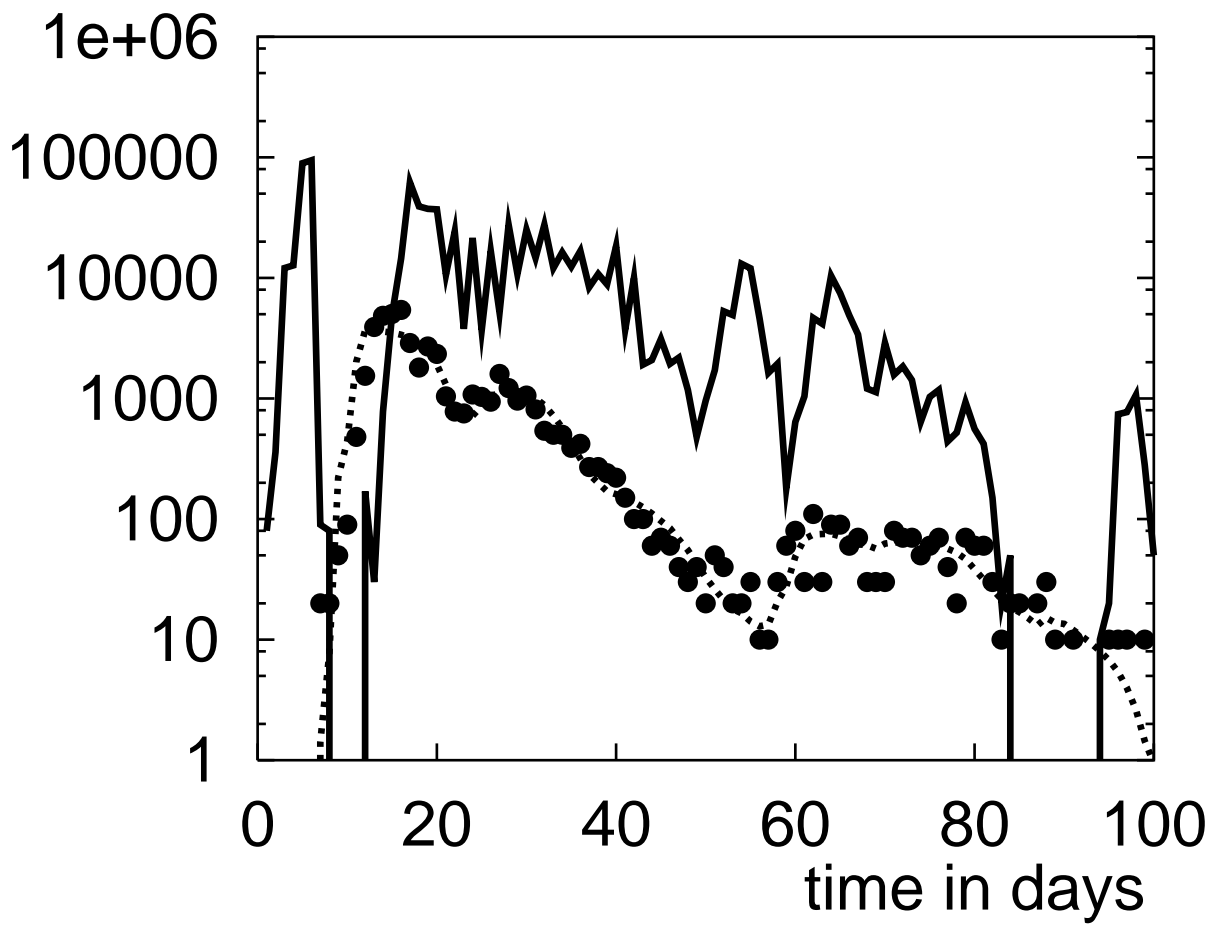
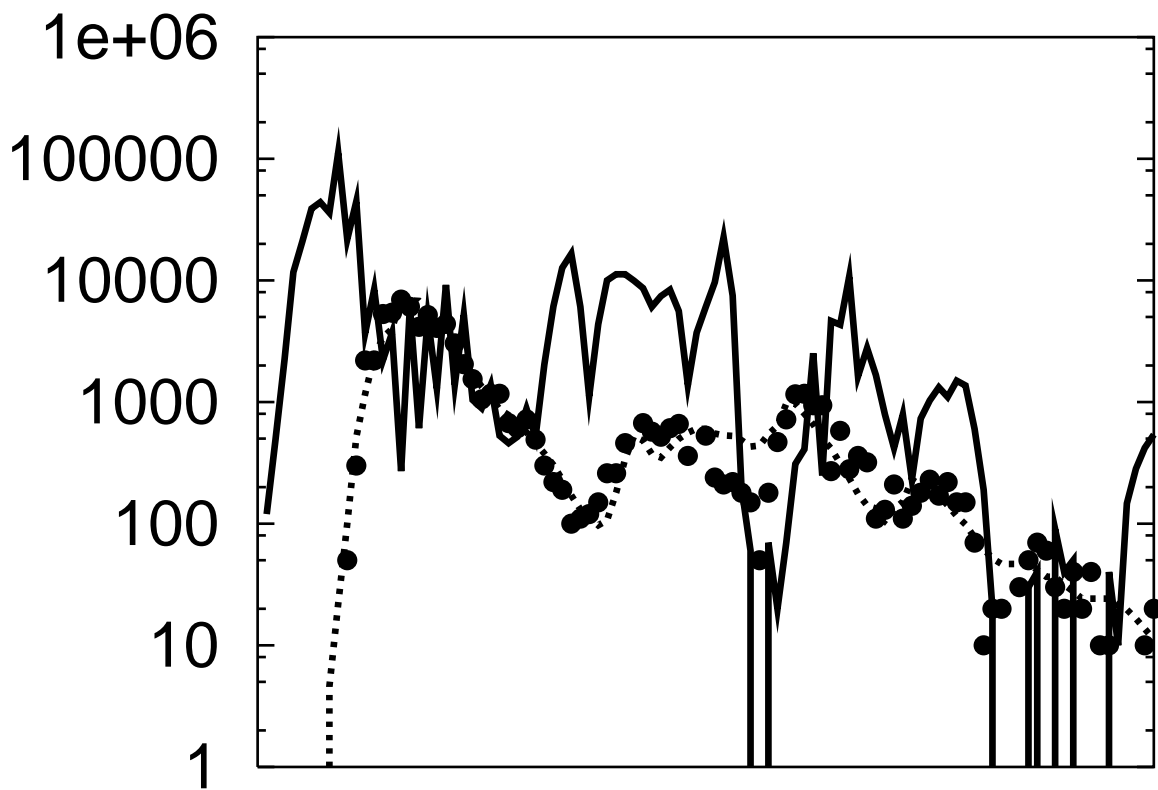
parasites per μl blood



0 20 40 60 80 100
time in days

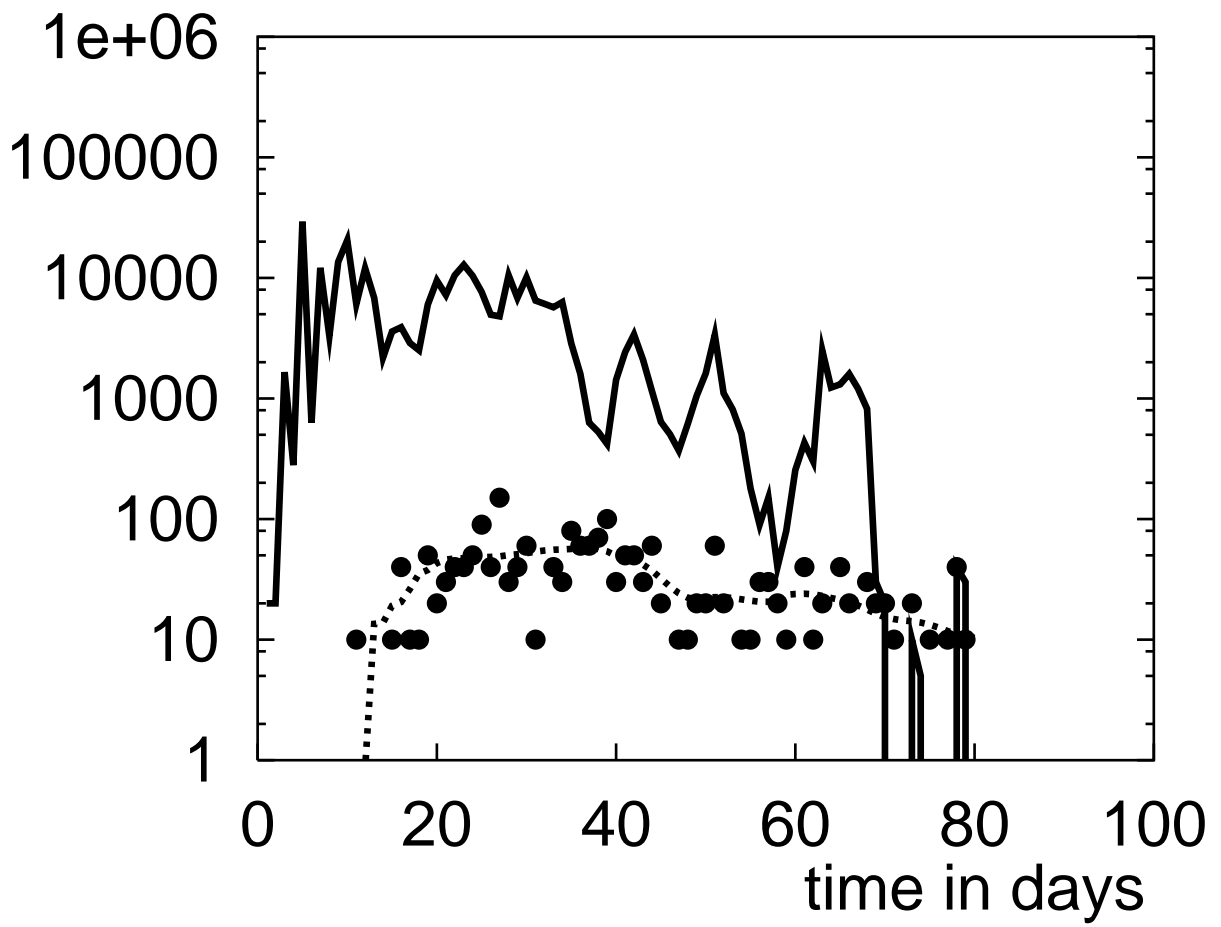
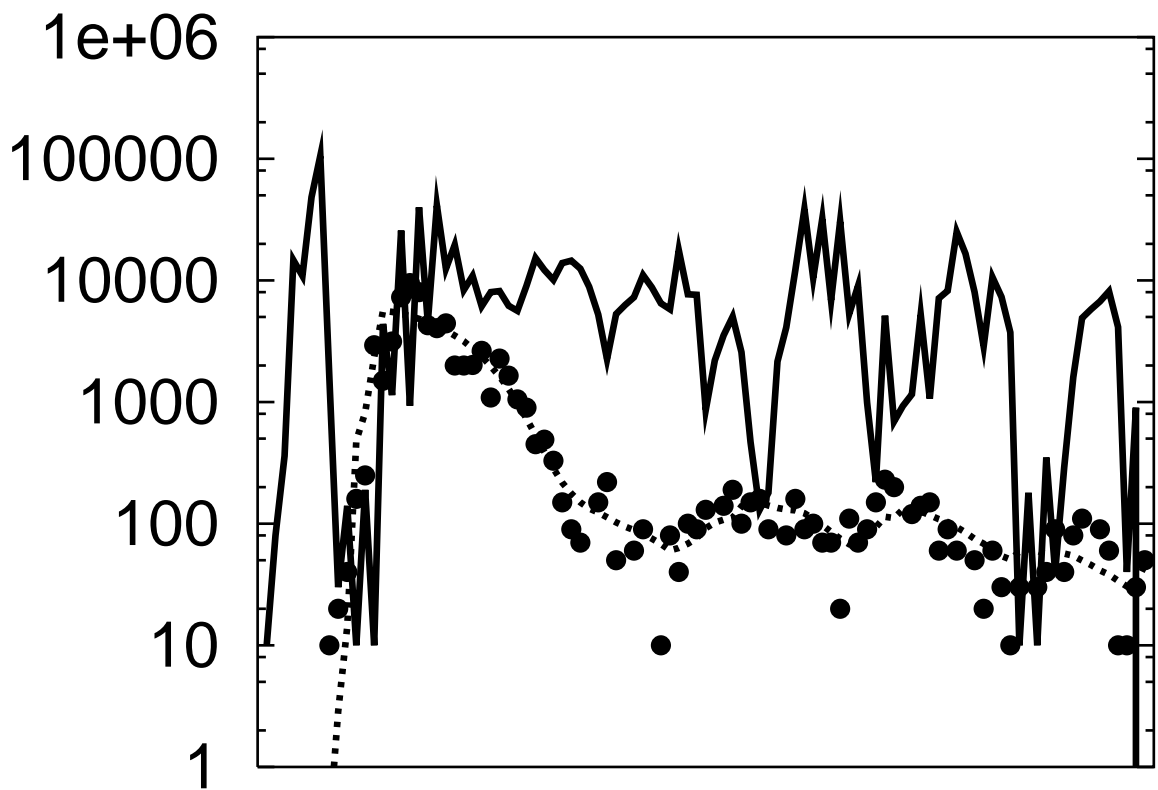
asex. parasites —
observ. gameto. •
expect gameto. ···

parasites per μl blood



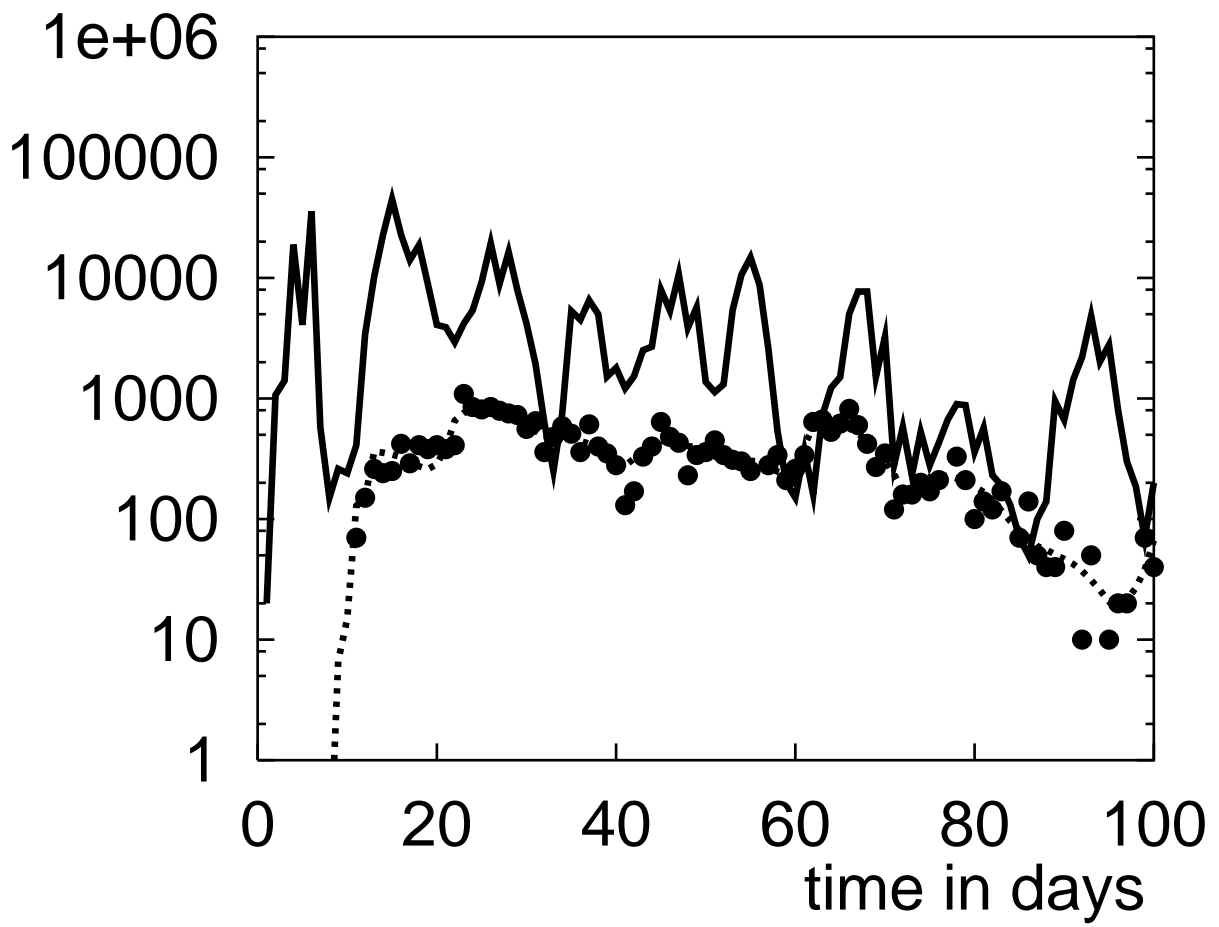
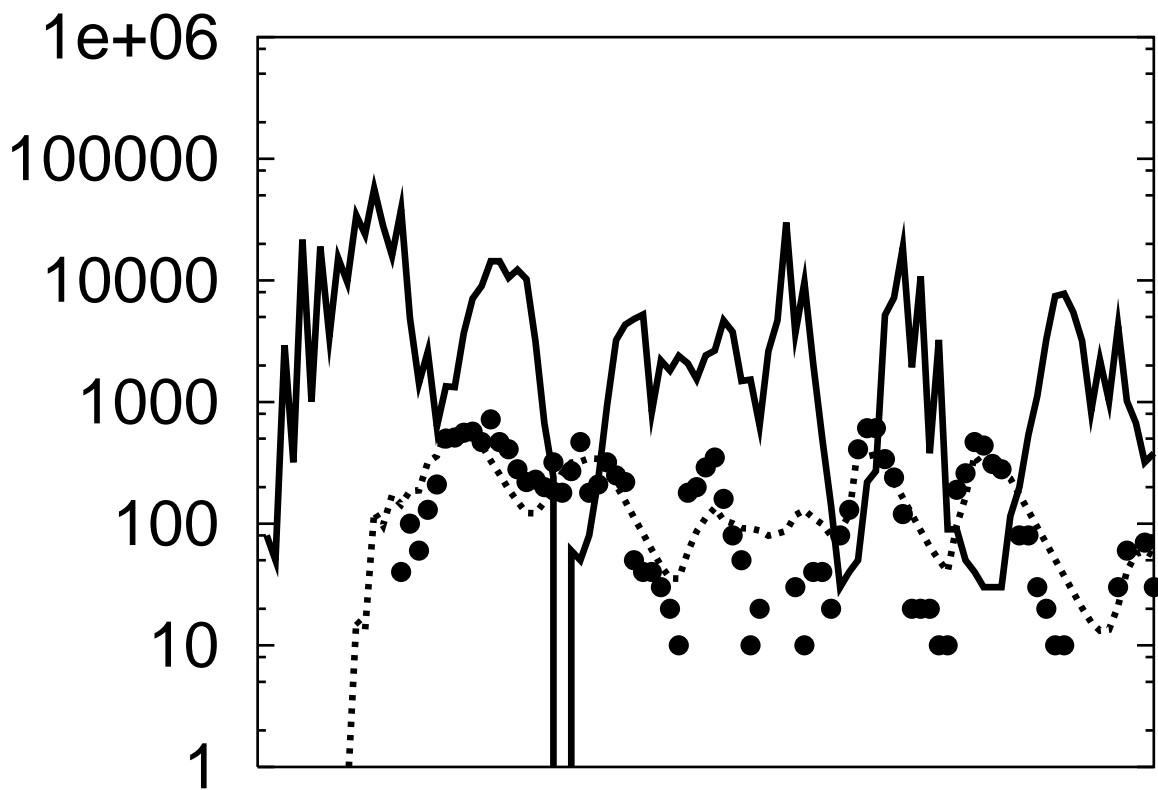
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



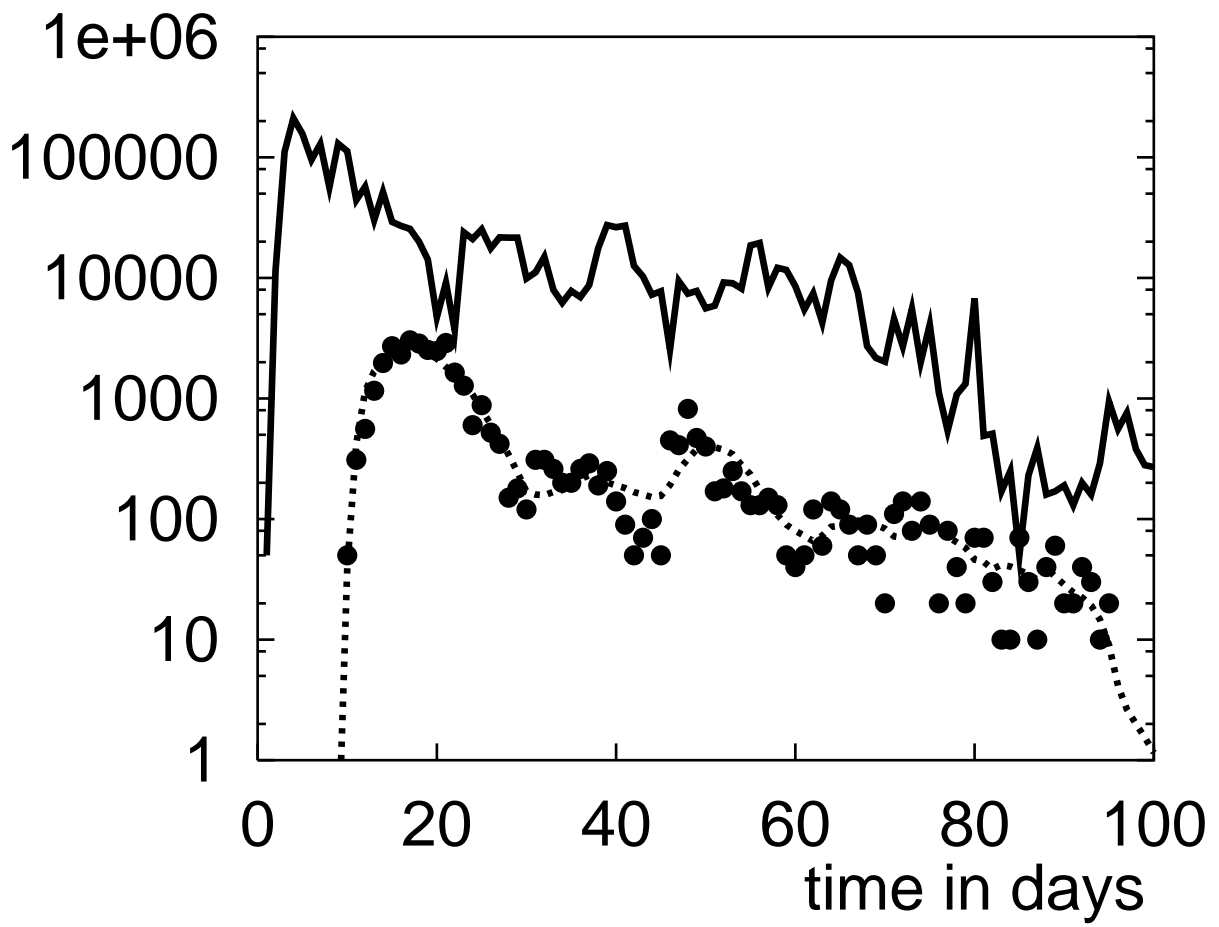
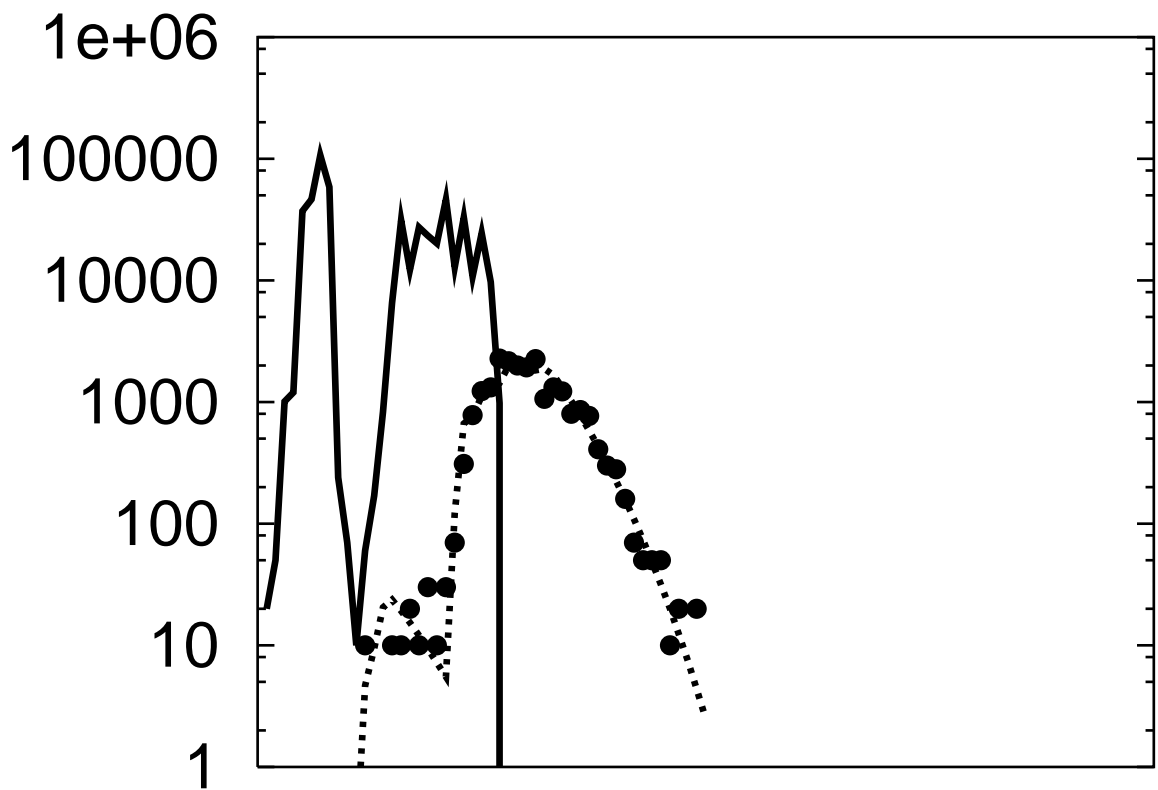
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



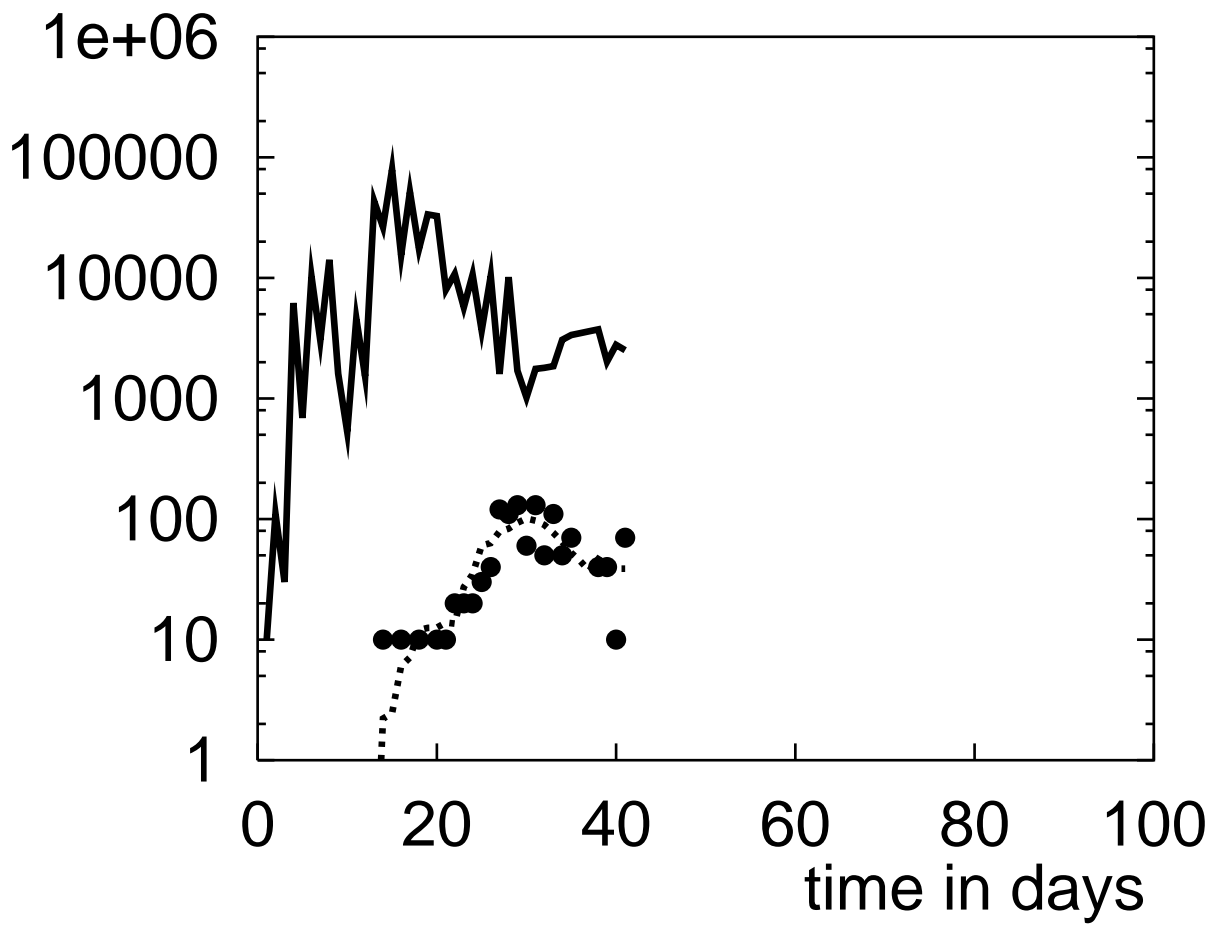
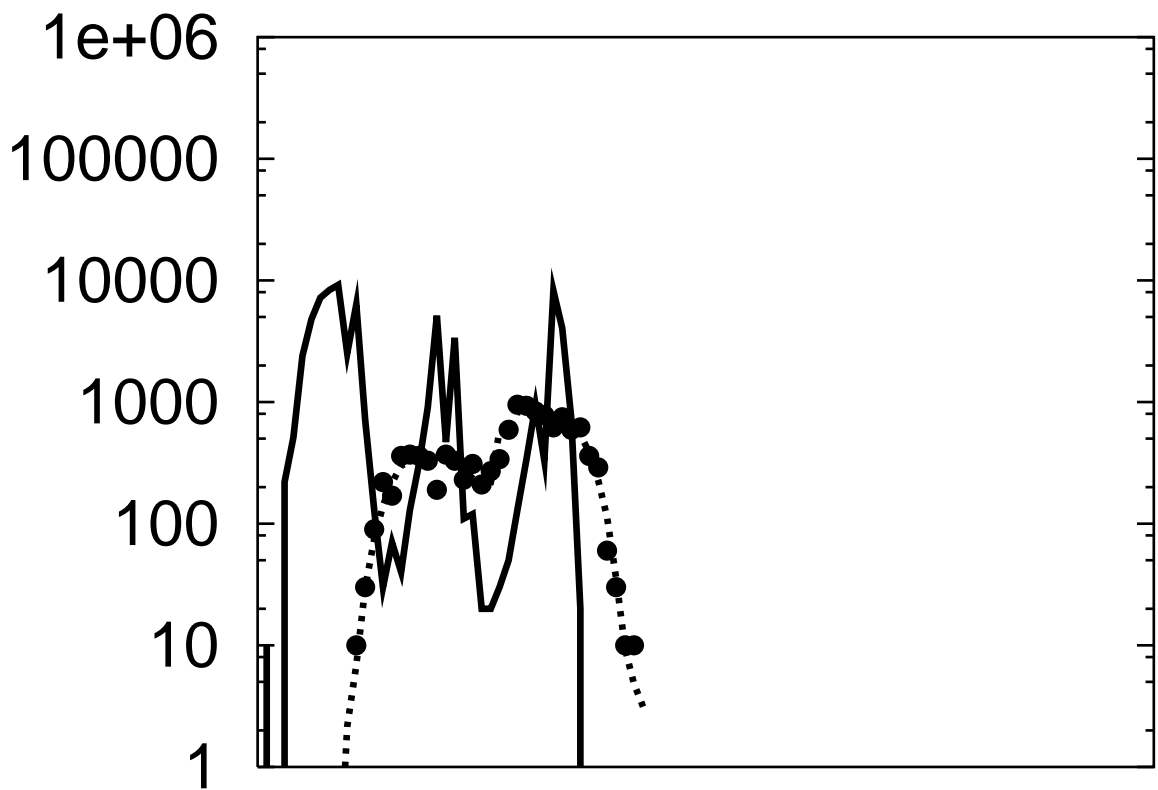
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



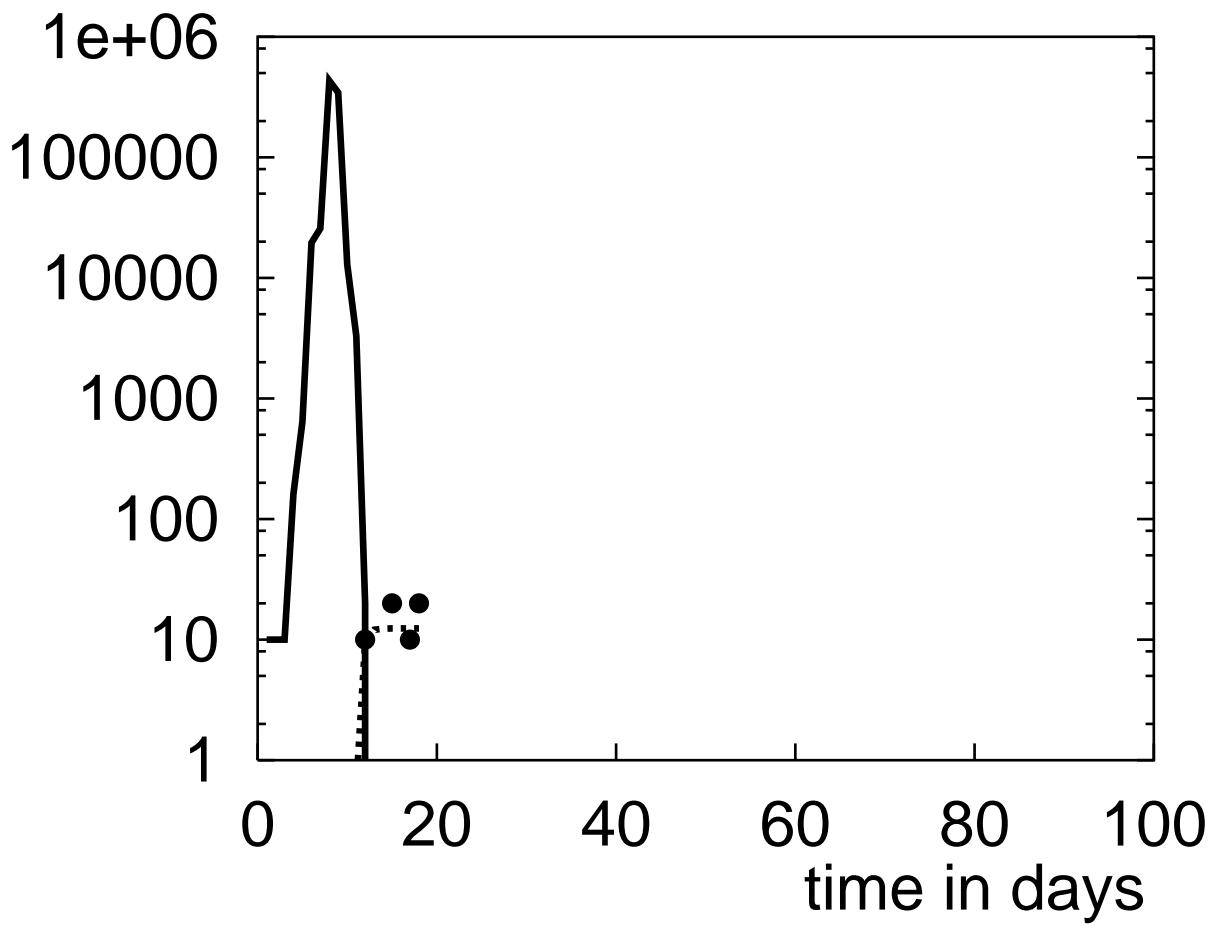
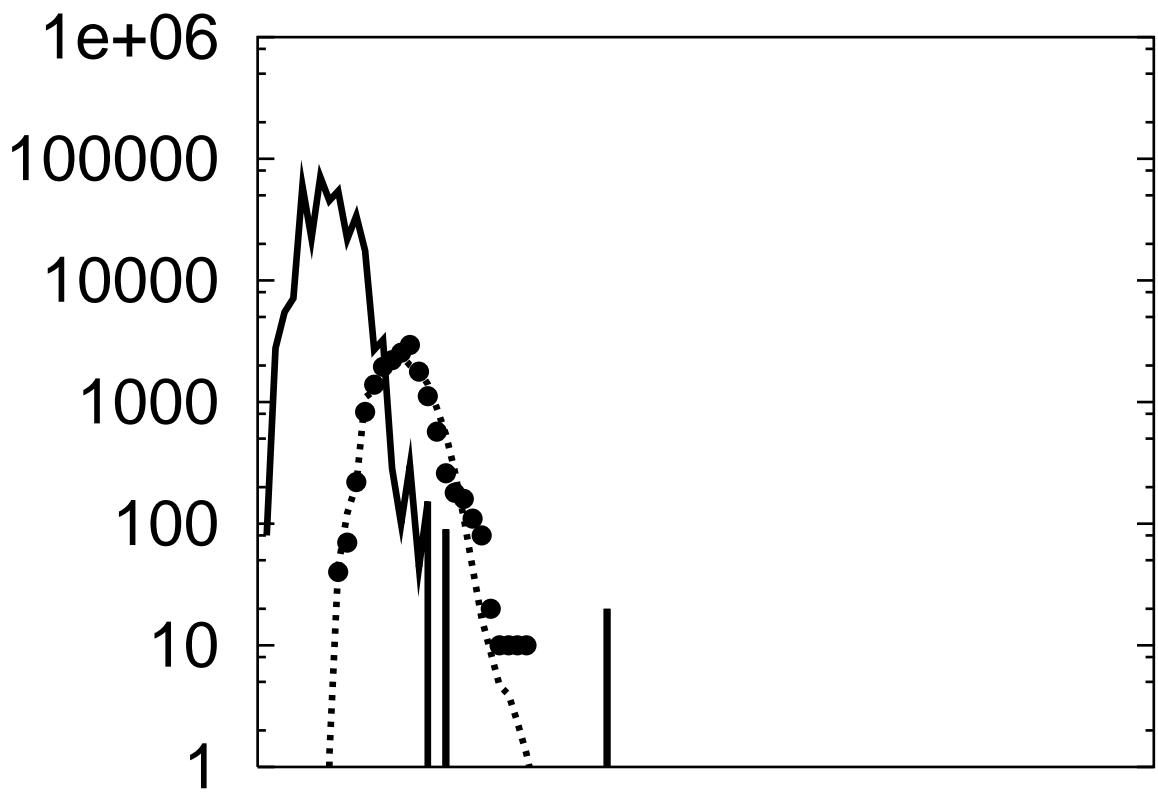
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



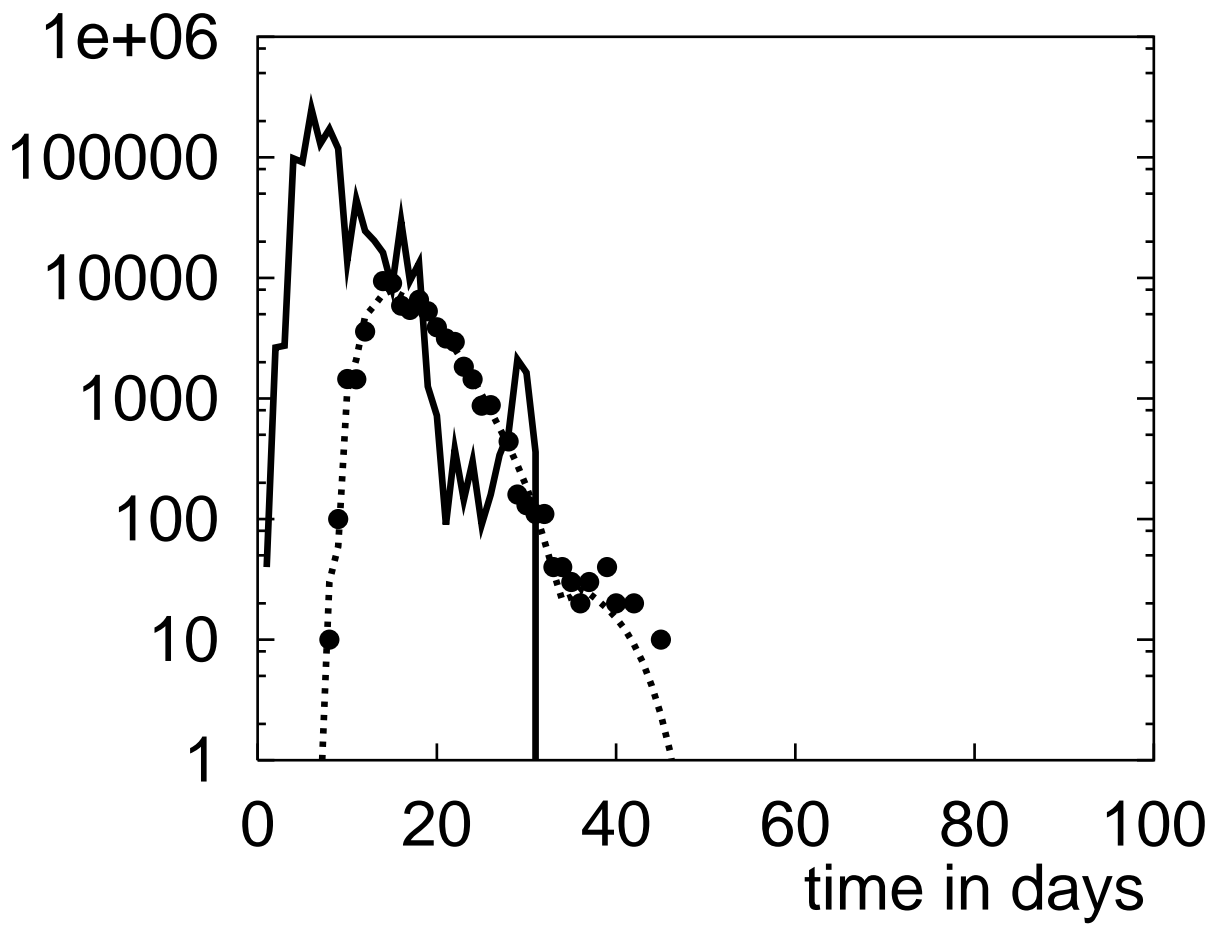
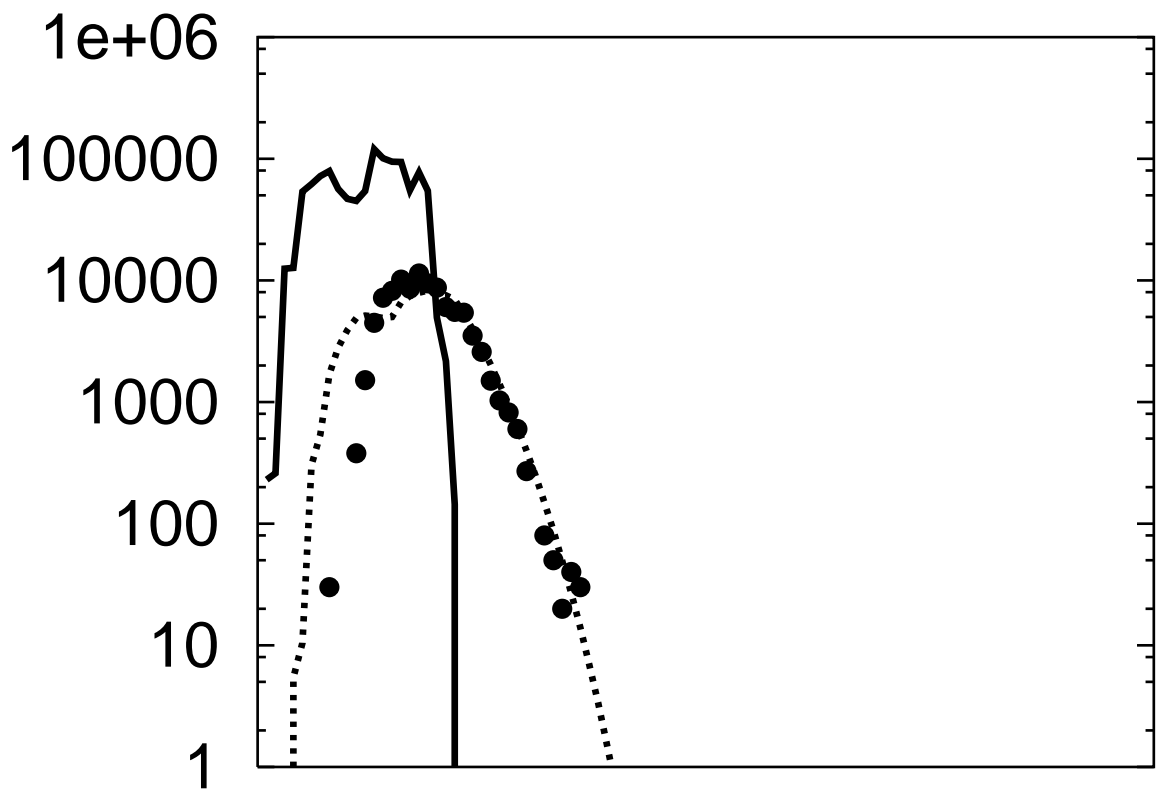
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



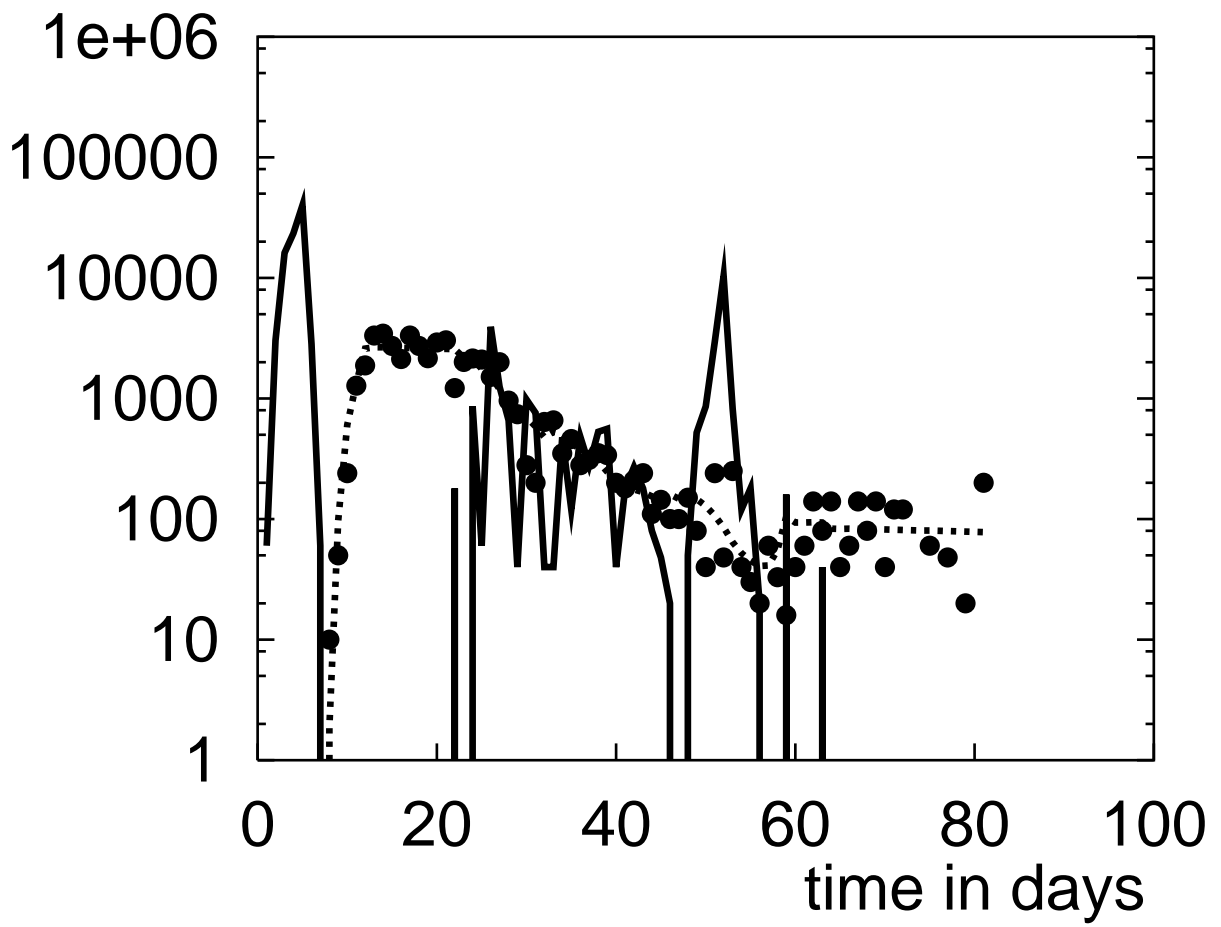
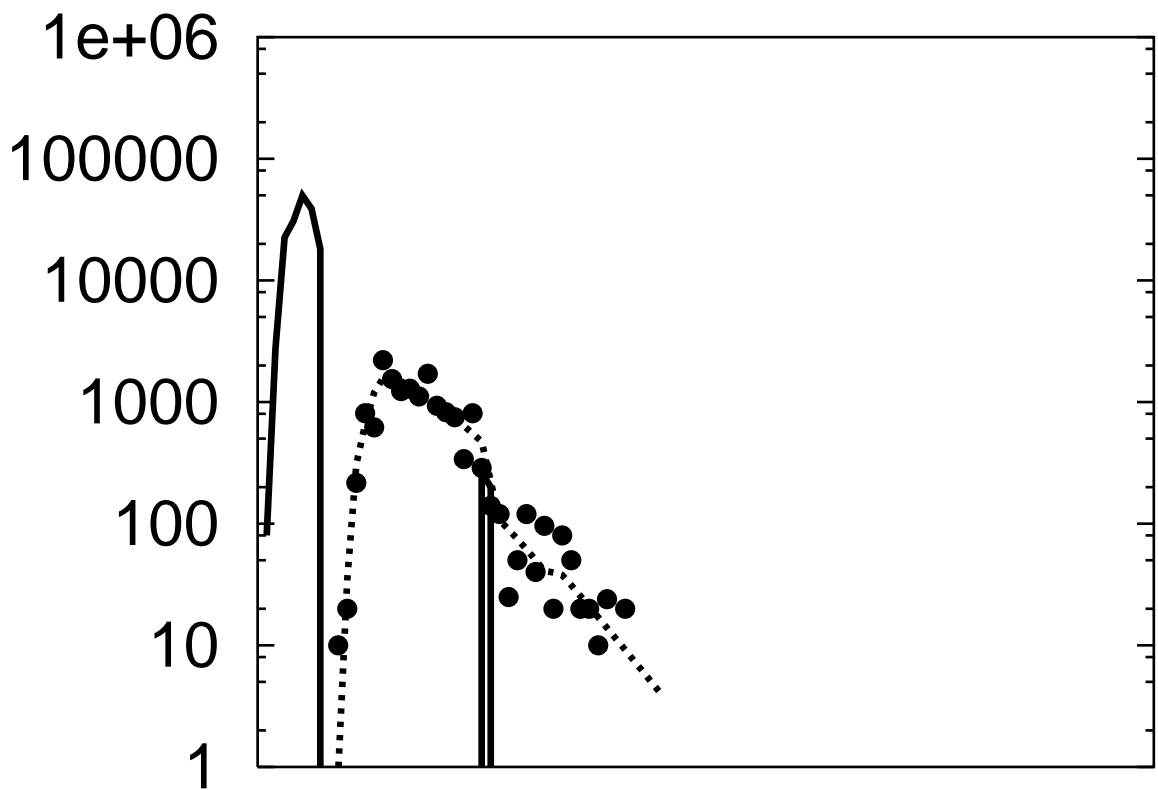
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



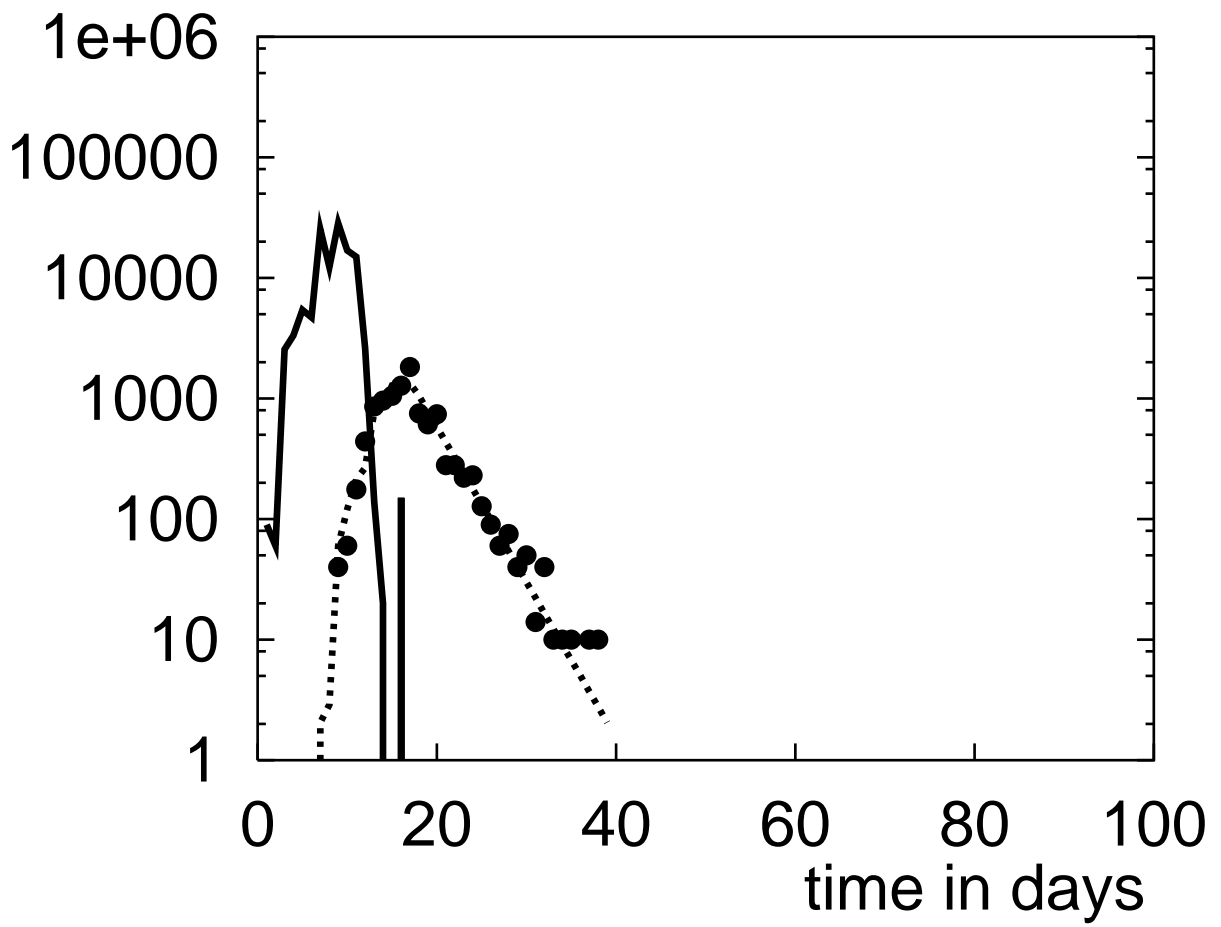
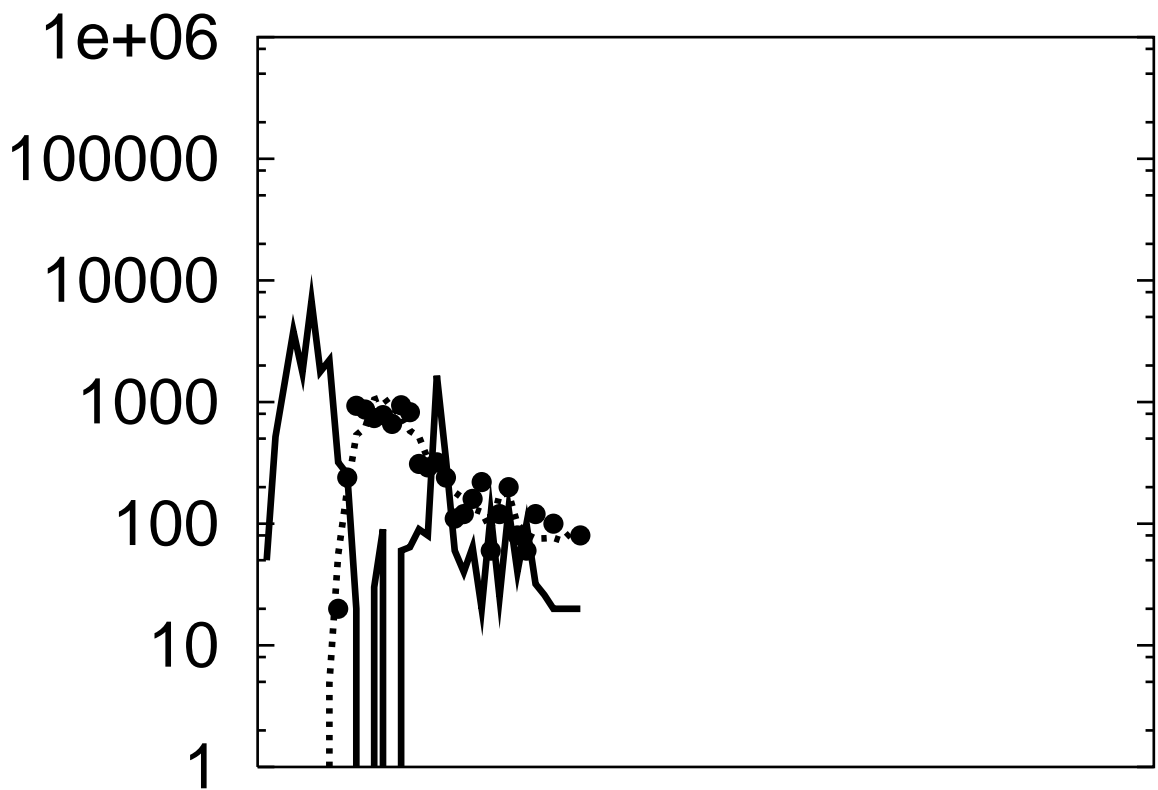
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



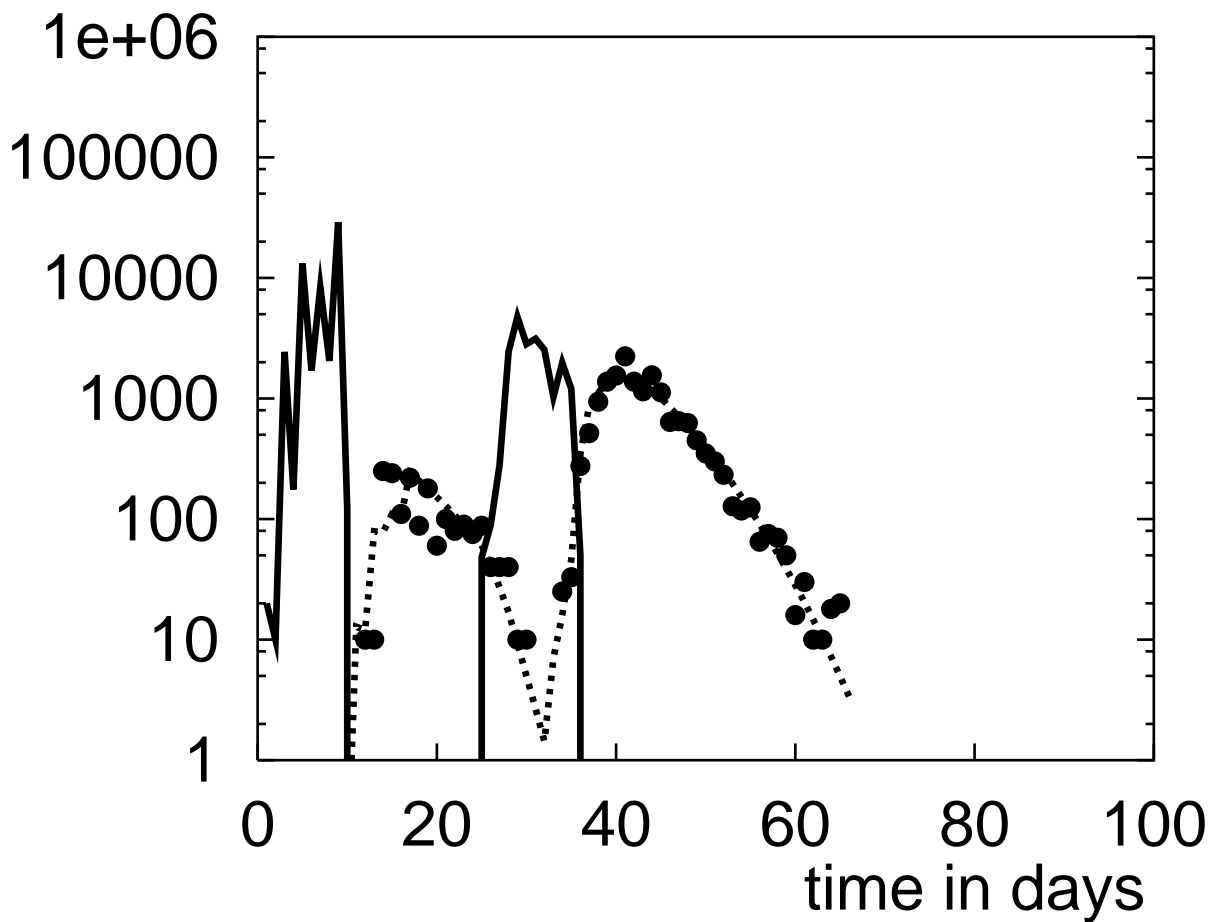
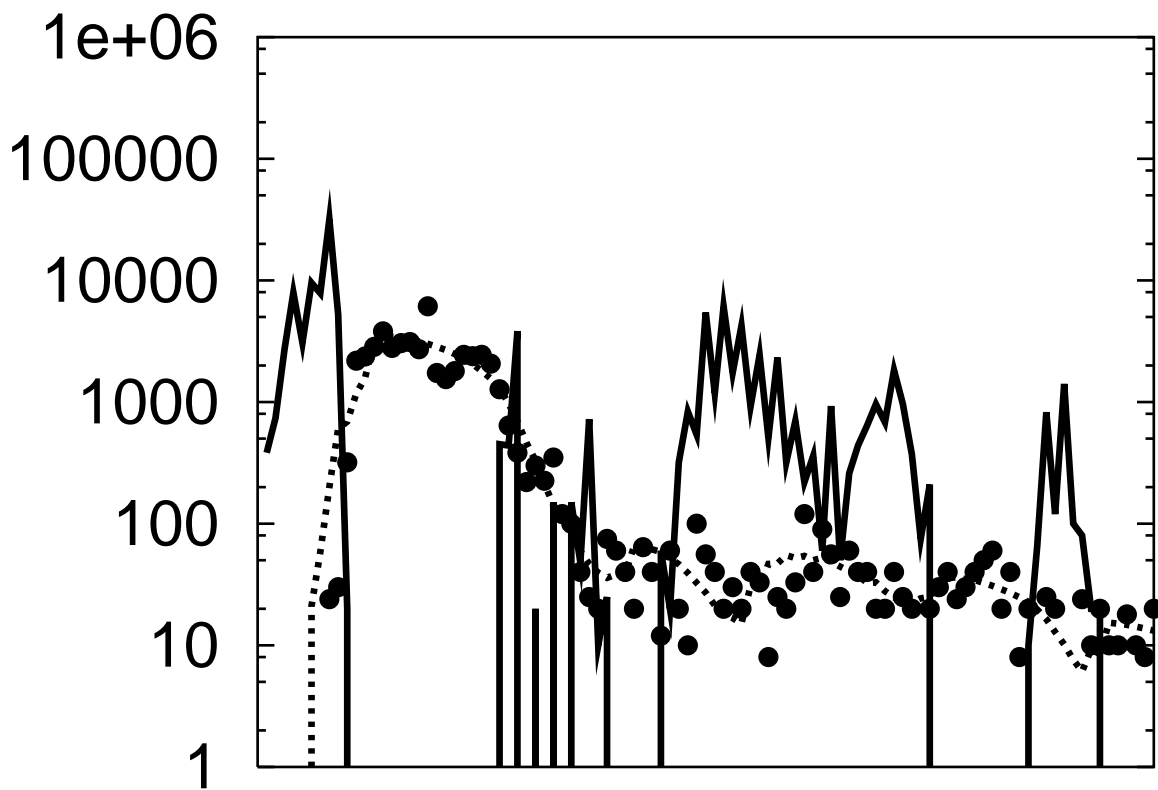
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



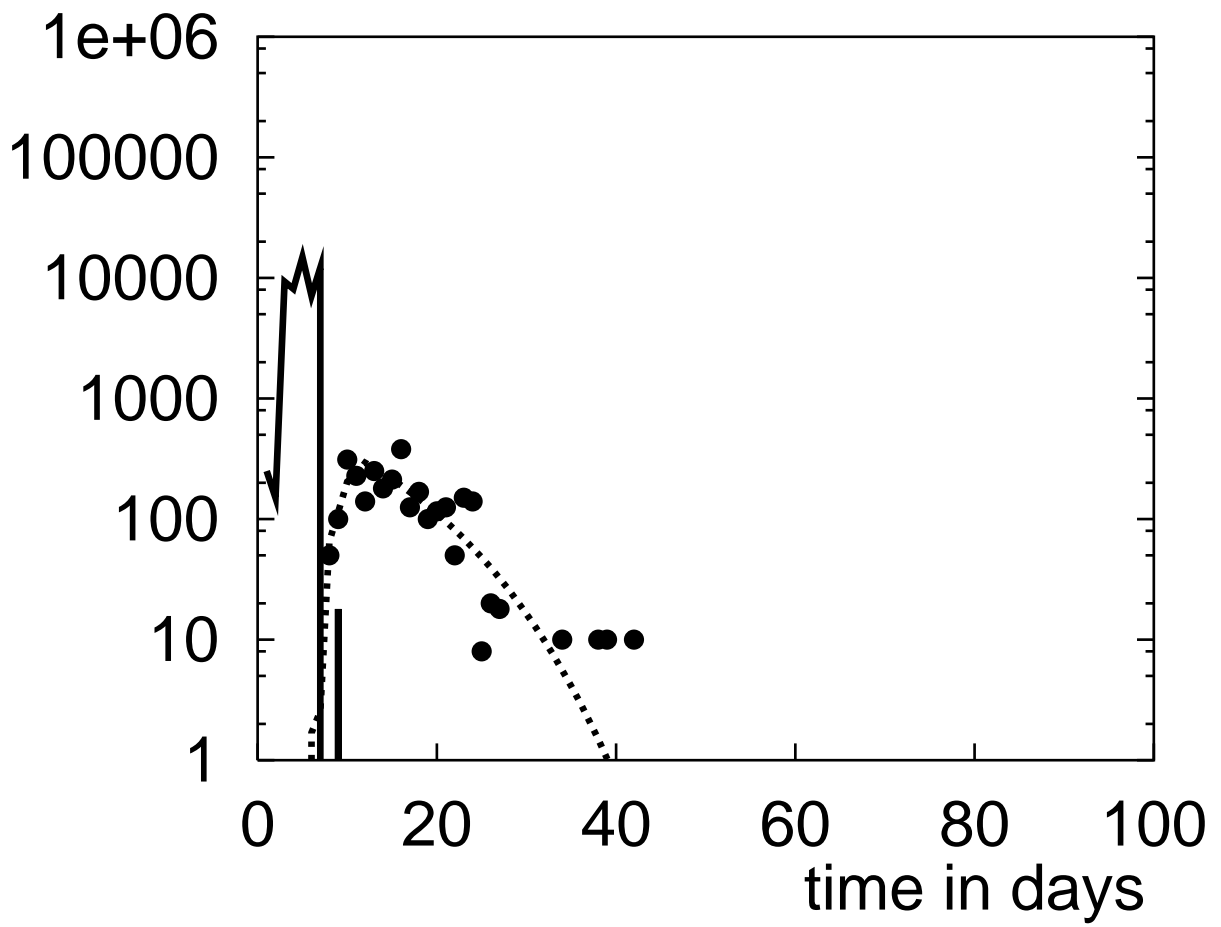
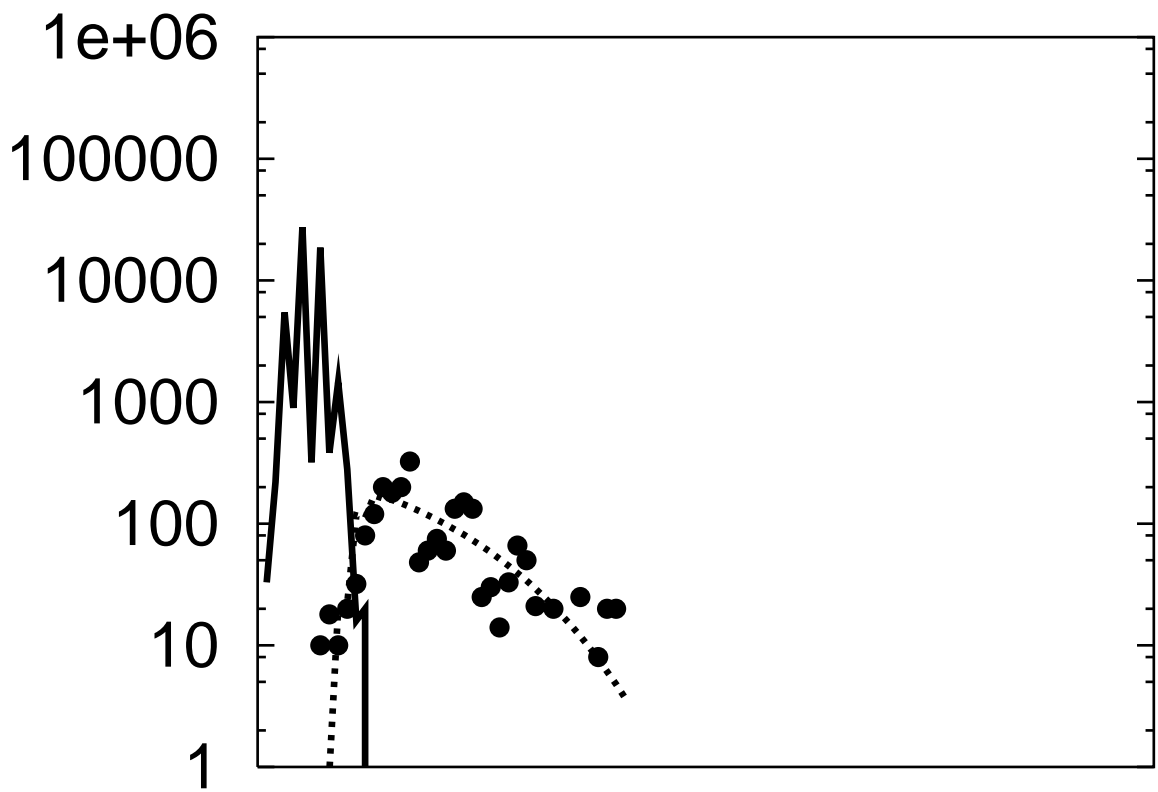
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



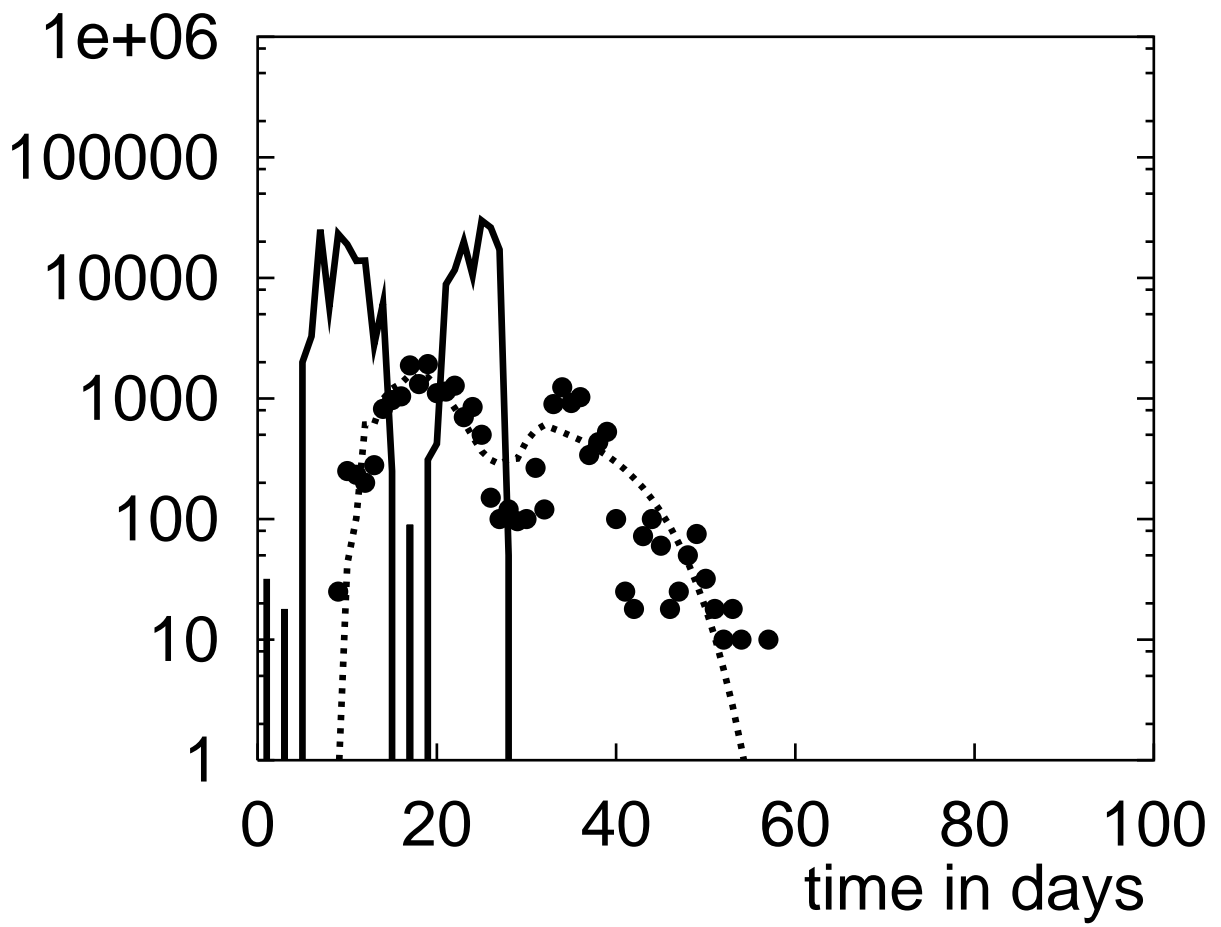
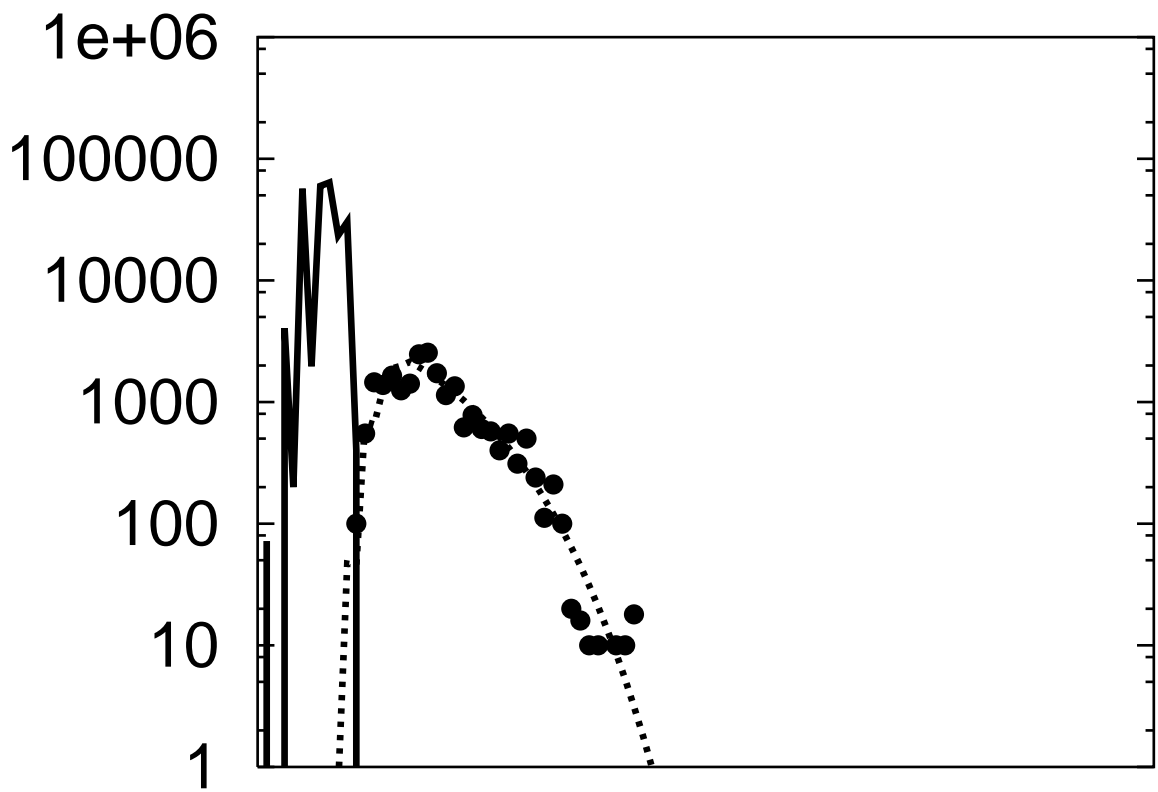
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



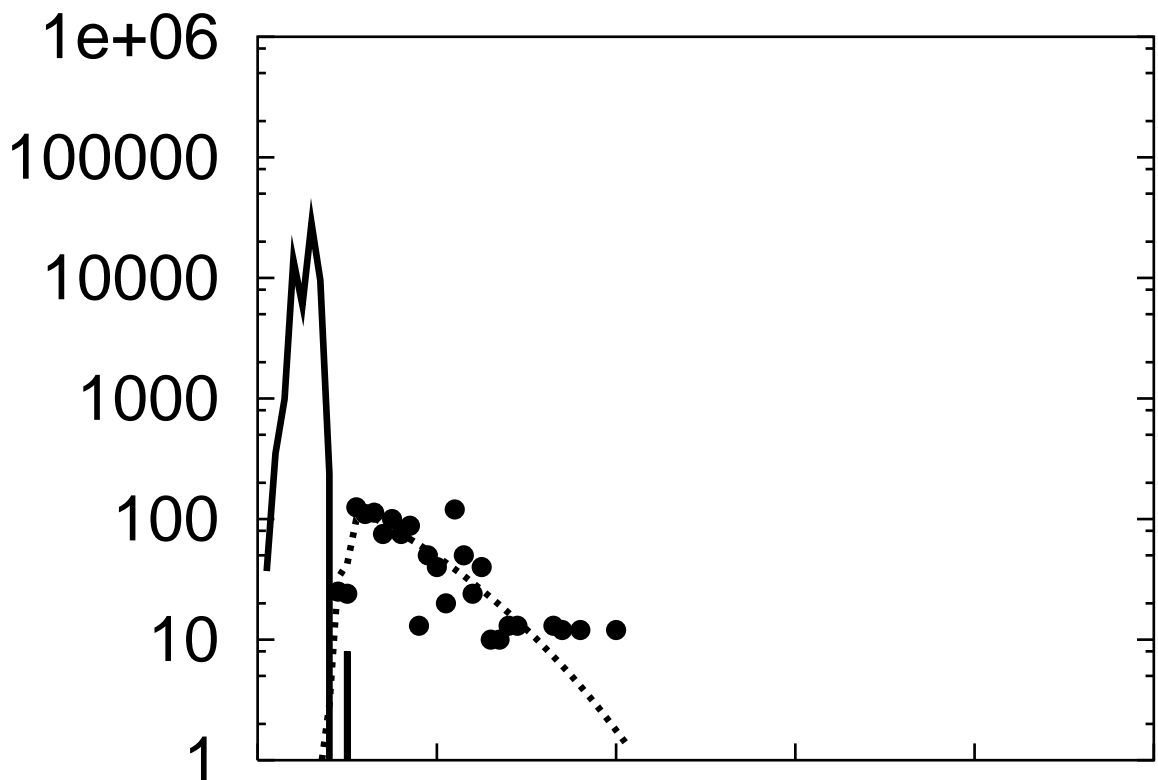
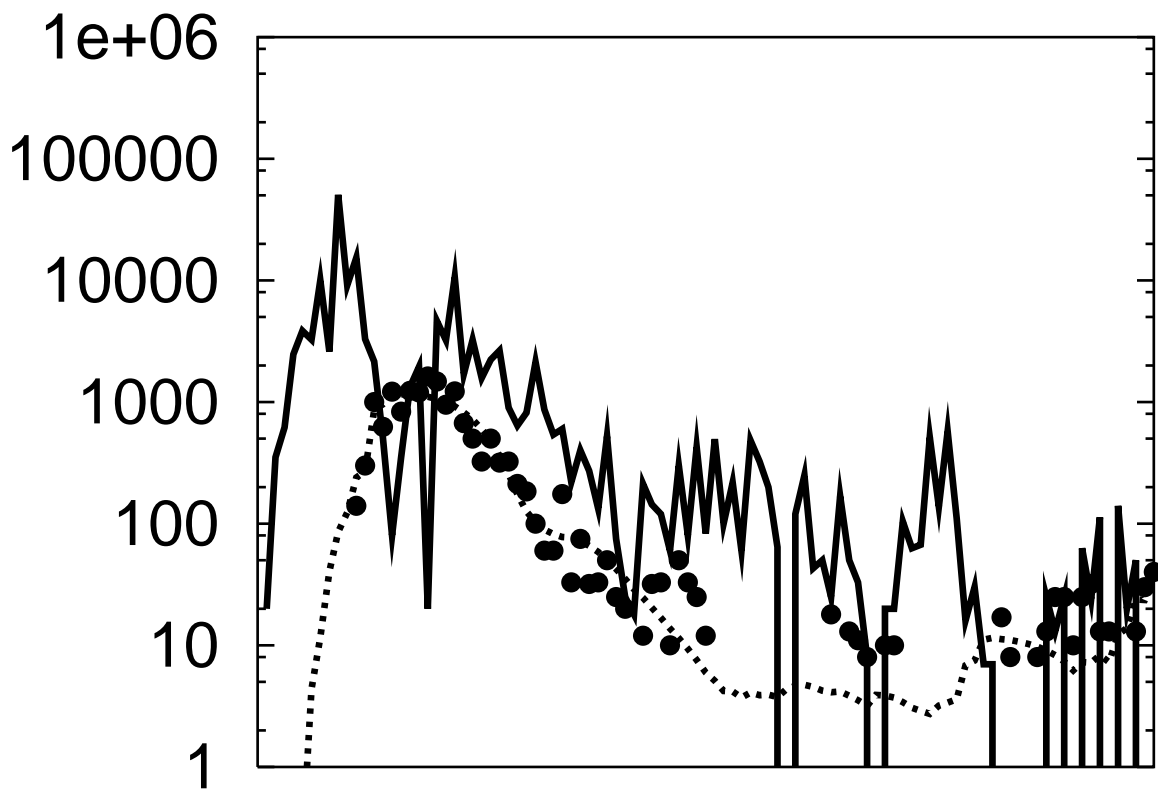
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



asex. parasites ———
observ. gameto. •
expect gameto. ·····

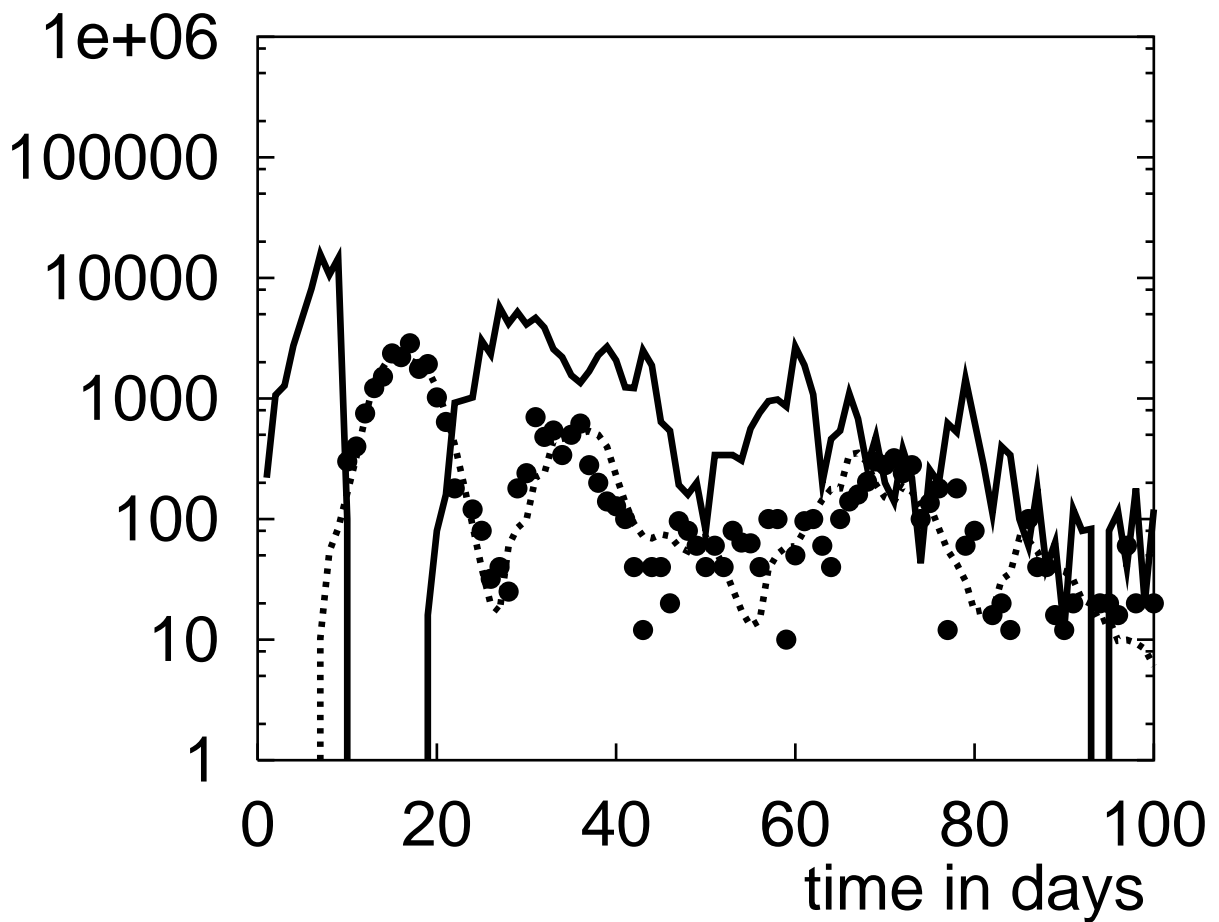
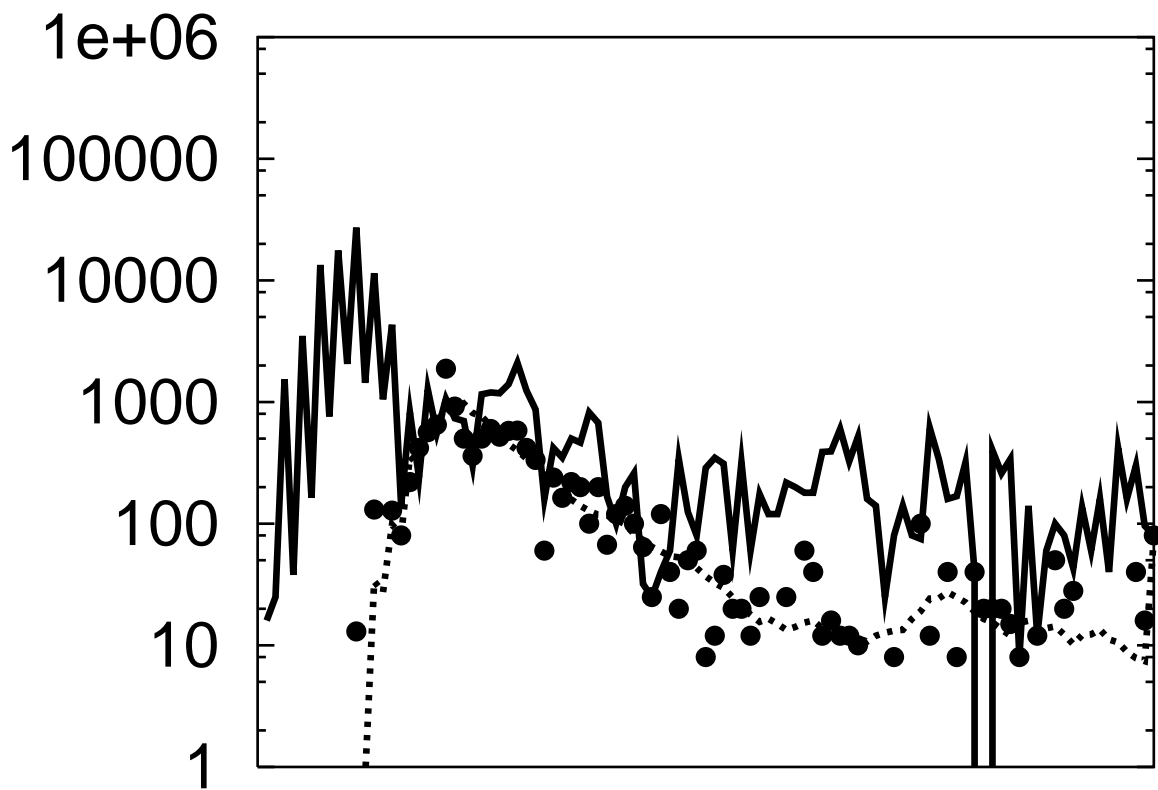
parasites per μl blood



0 20 40 60 80 100
time in days

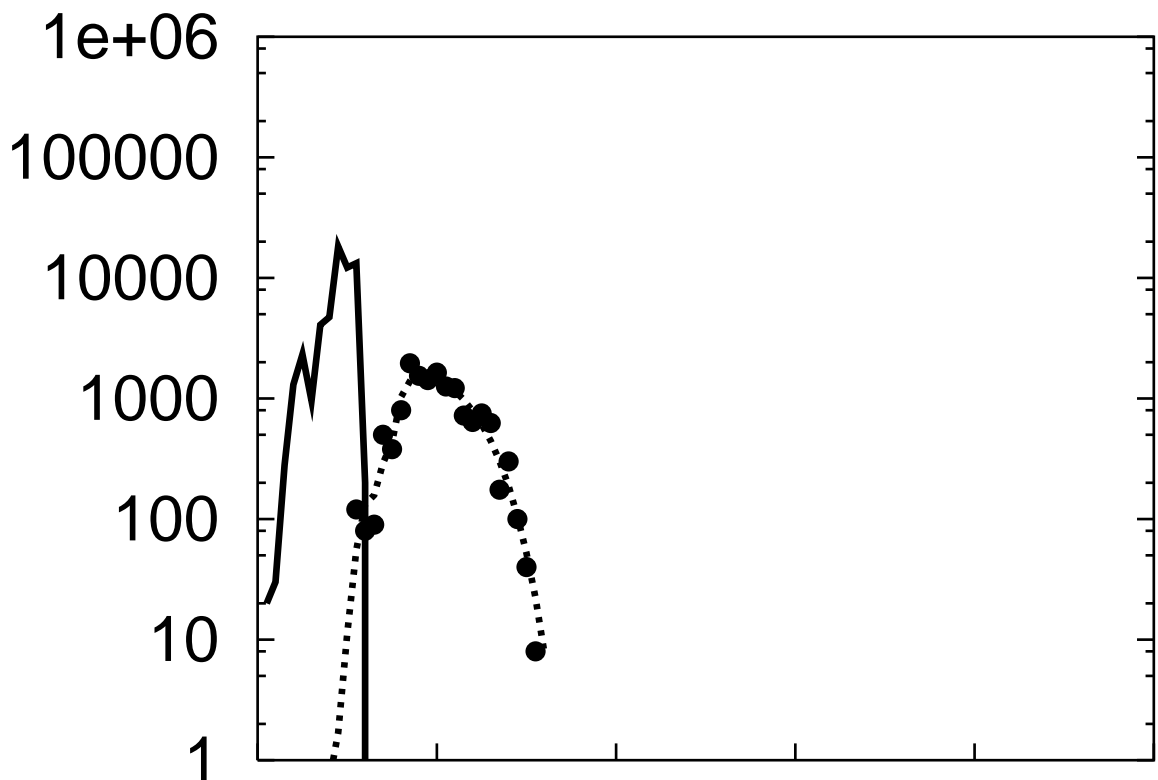
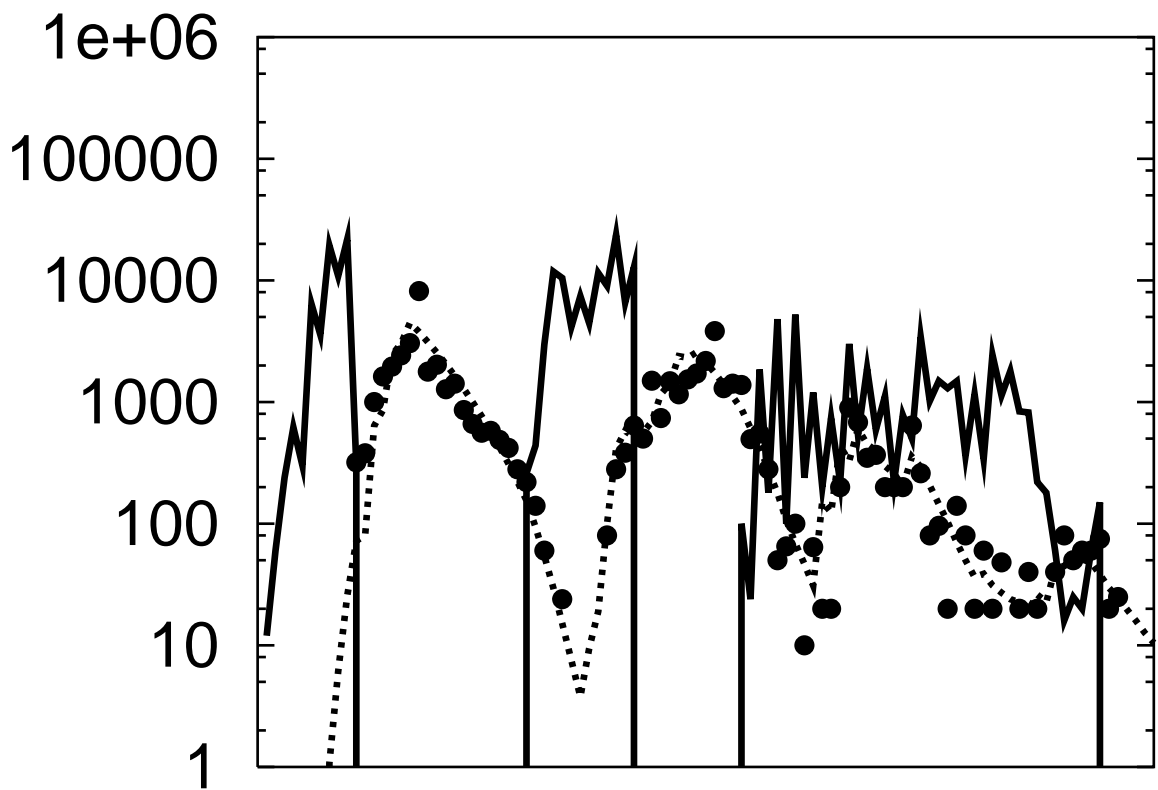
asex. parasites —
observ. gameto. •
expect gameto. ·····

parasites per μl blood



asex. parasites ———
observ. gameto. •
expect gameto. ·····

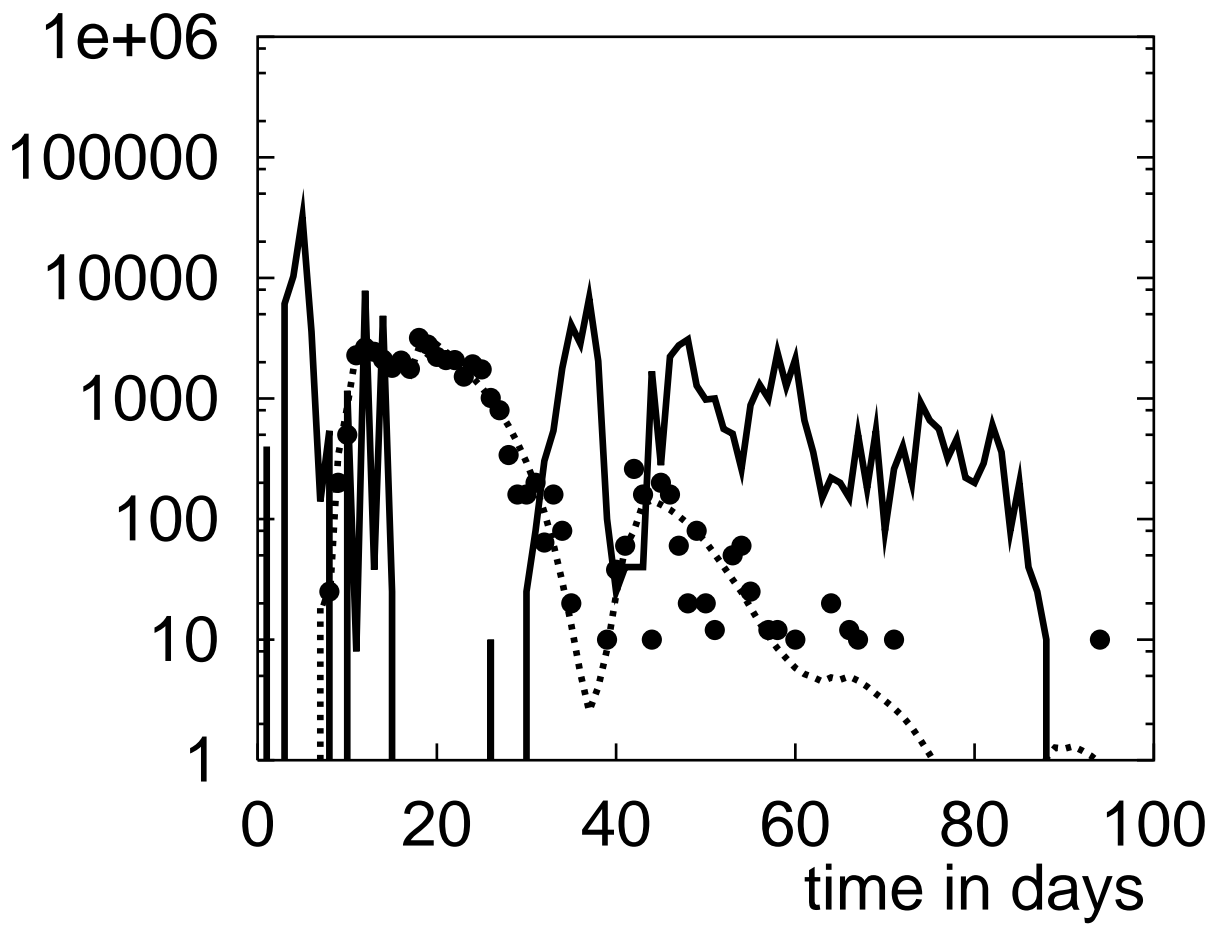
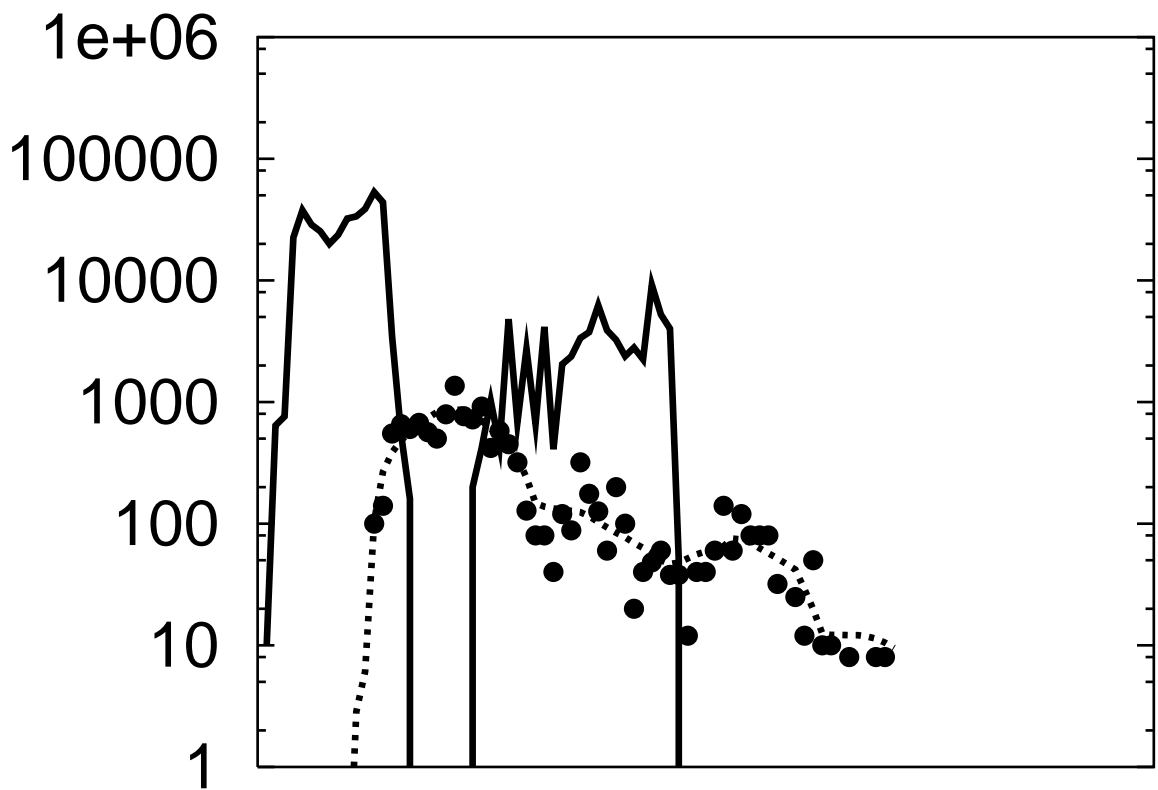
parasites per μl blood



0 20 40 60 80 100
time in days

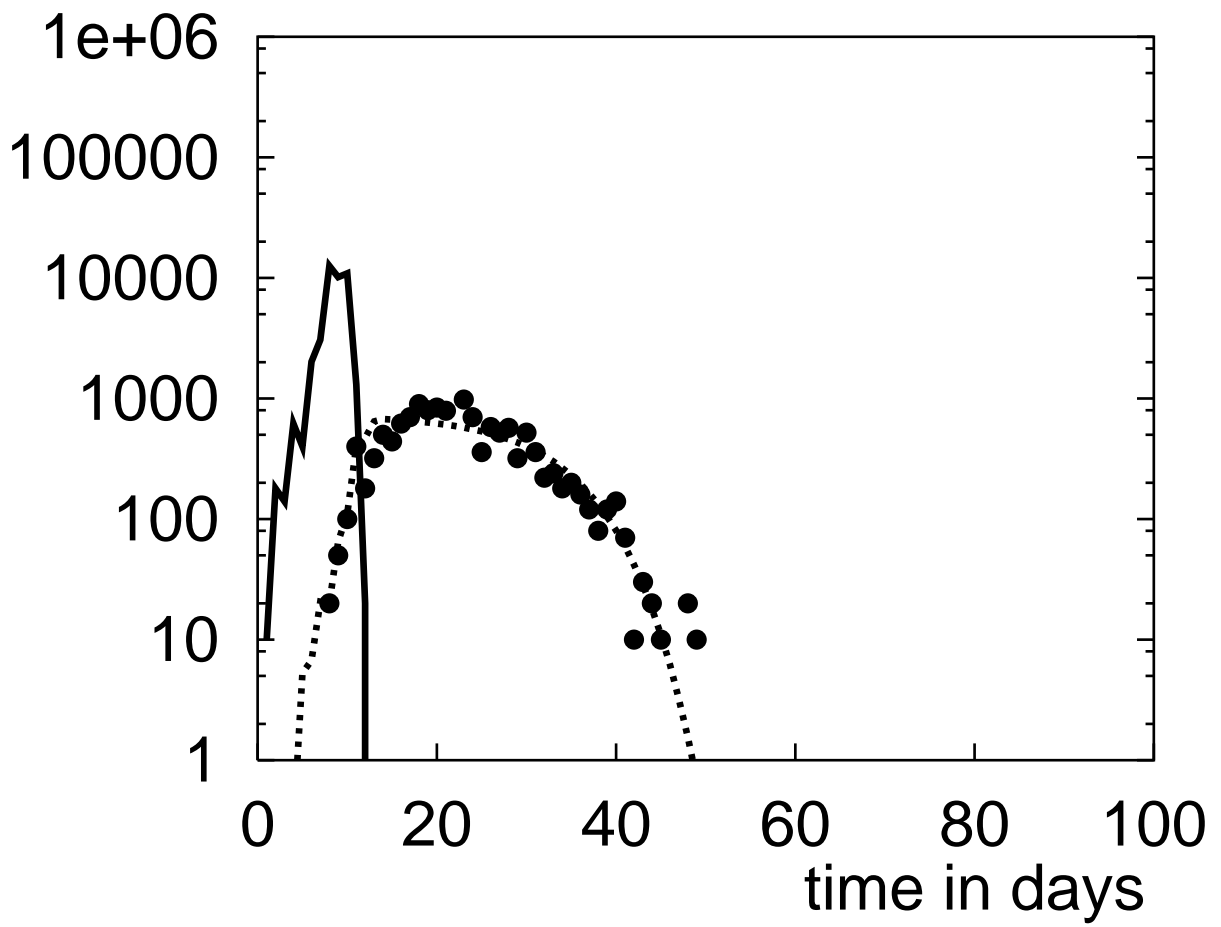
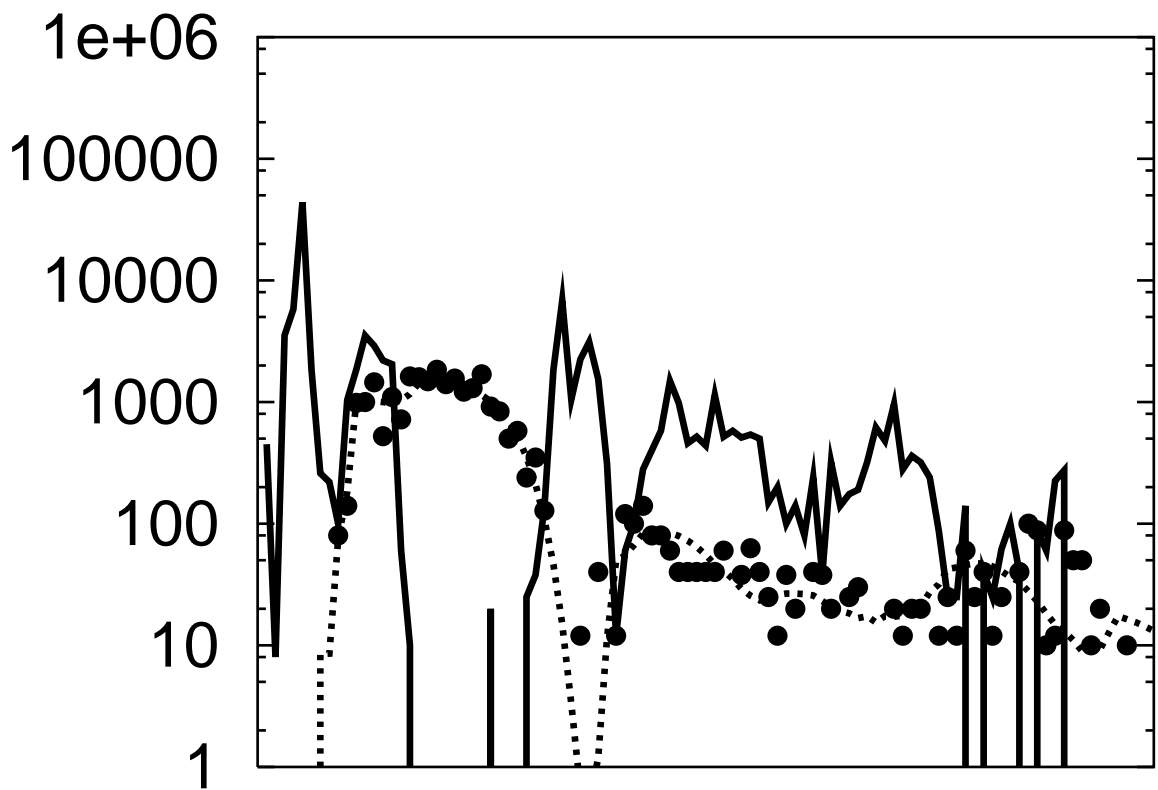
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



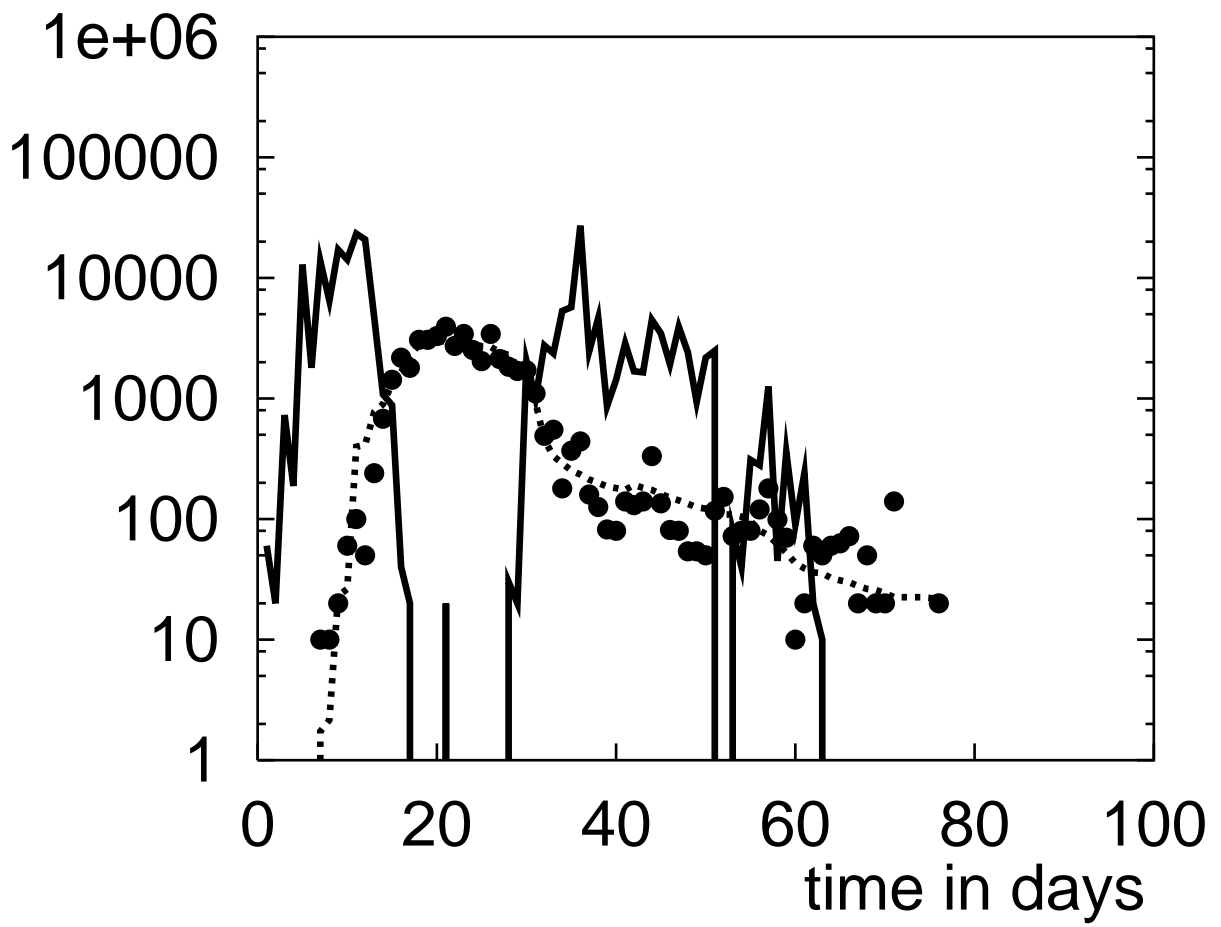
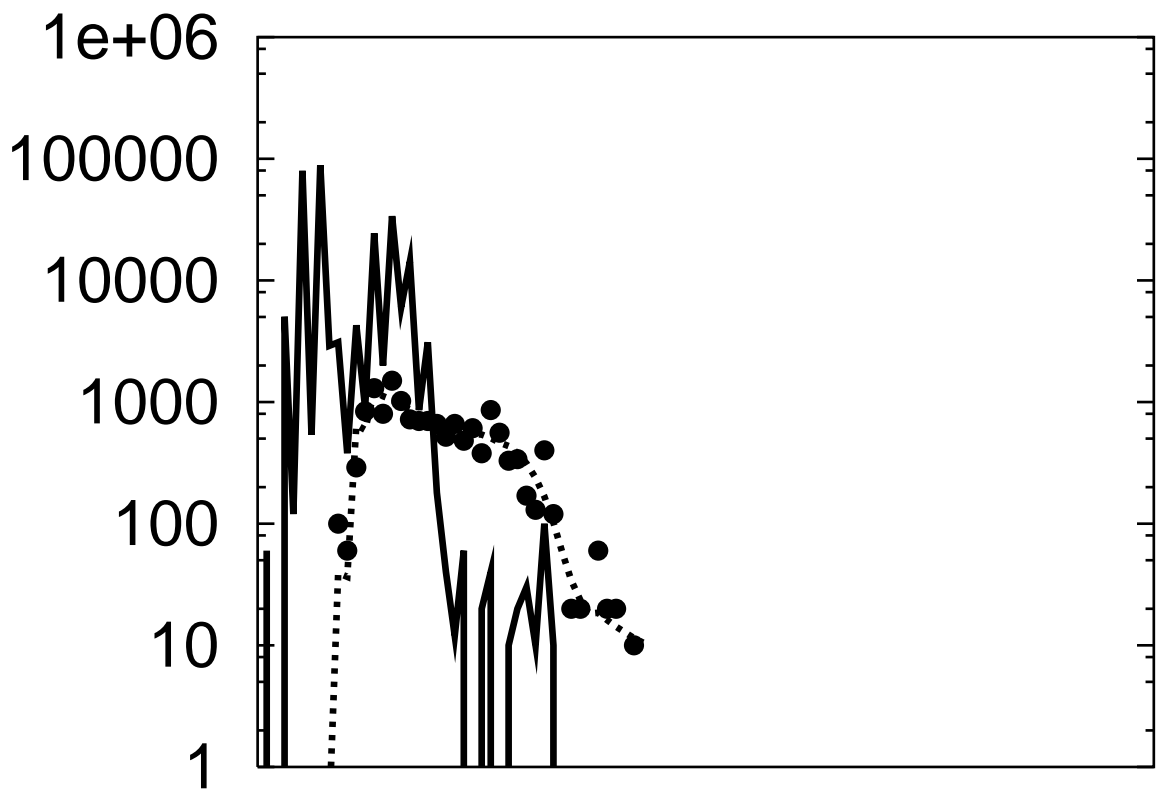
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



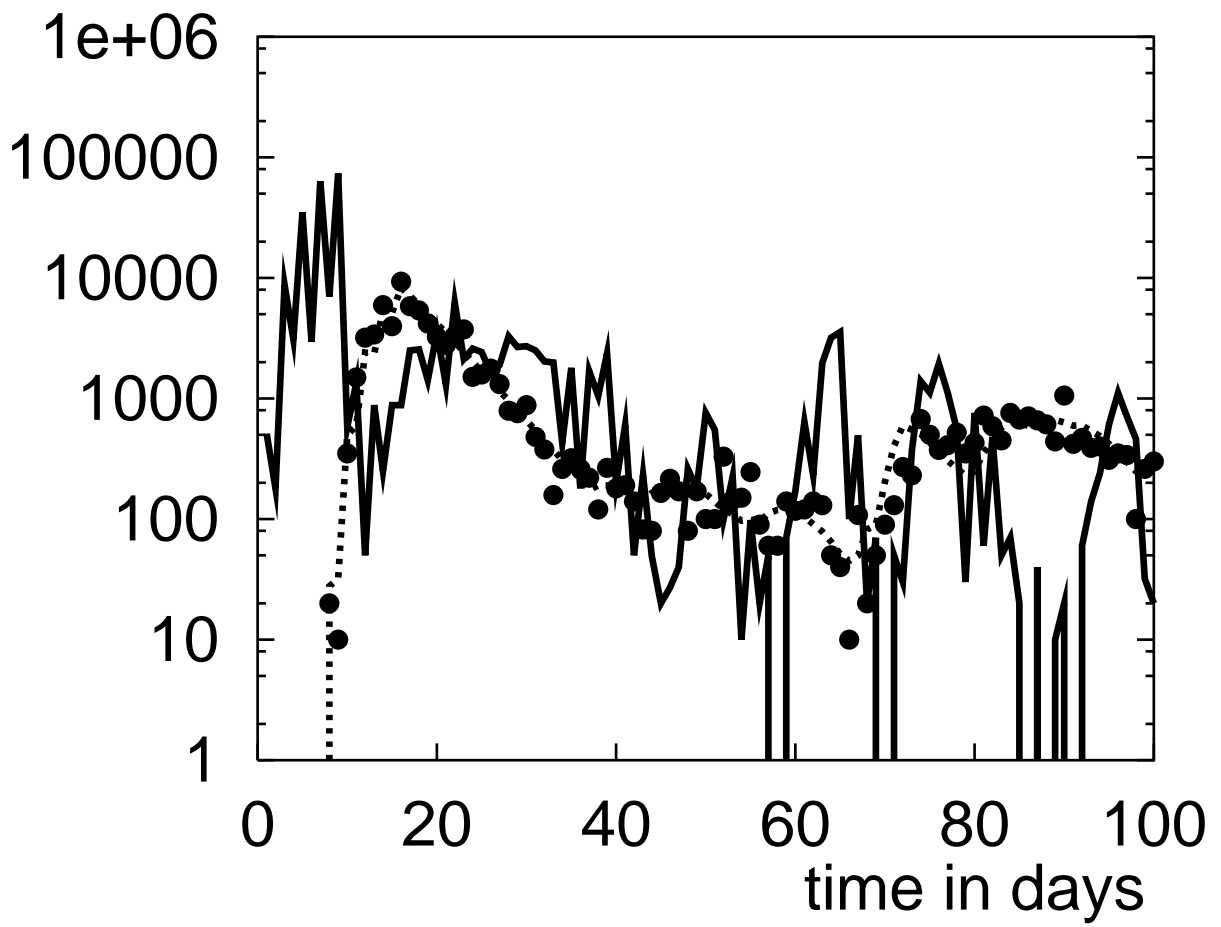
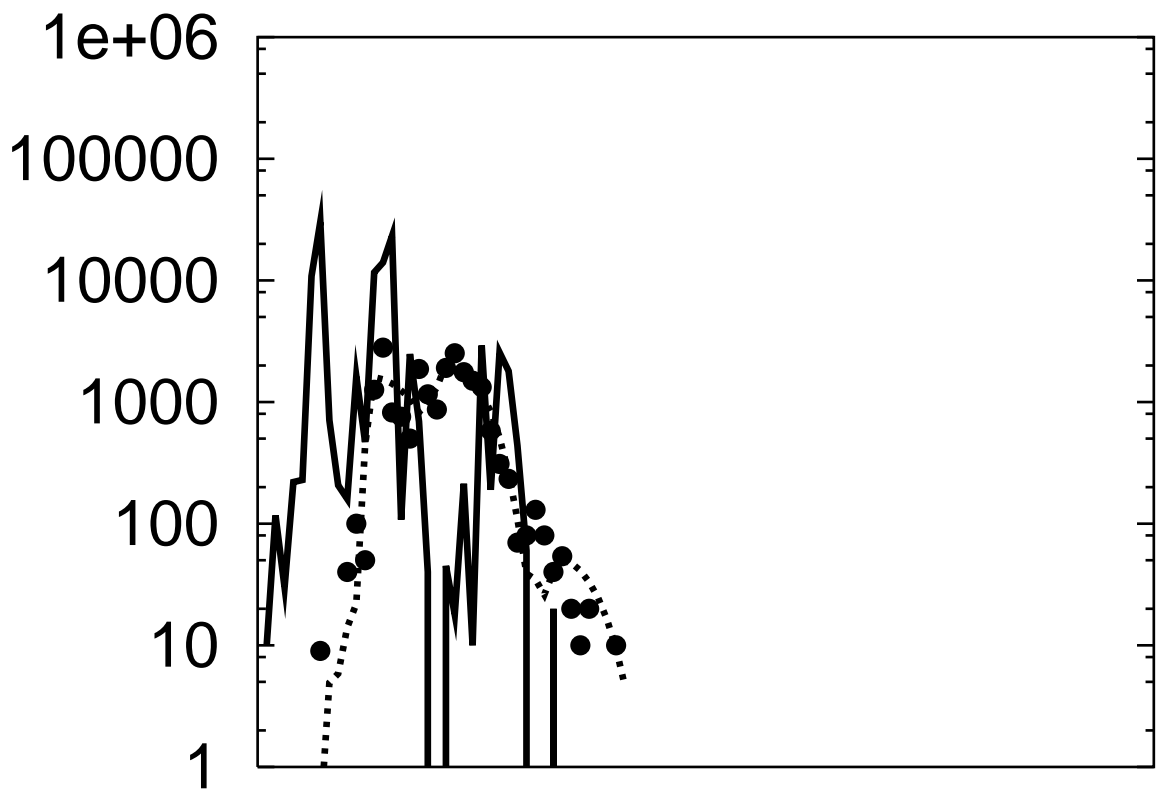
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



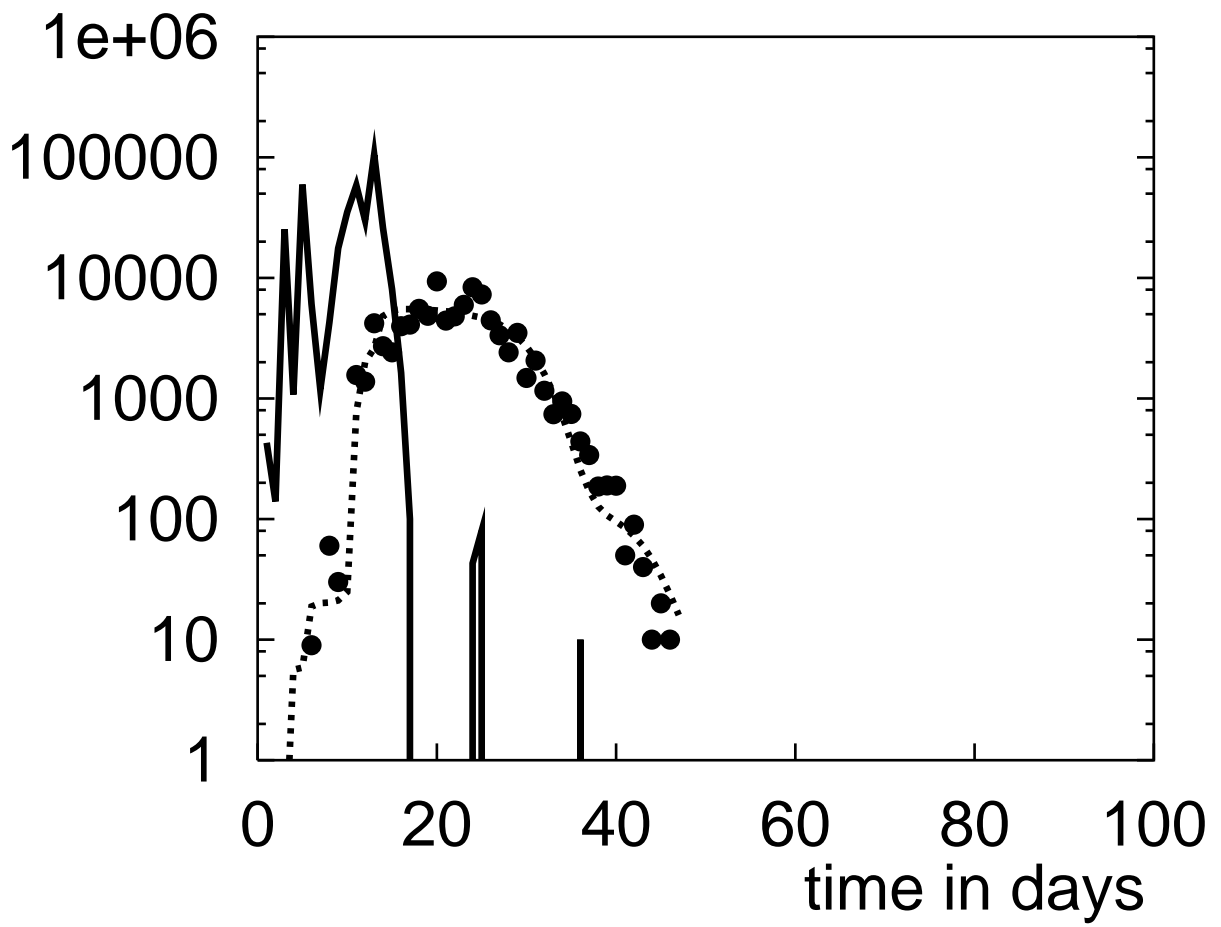
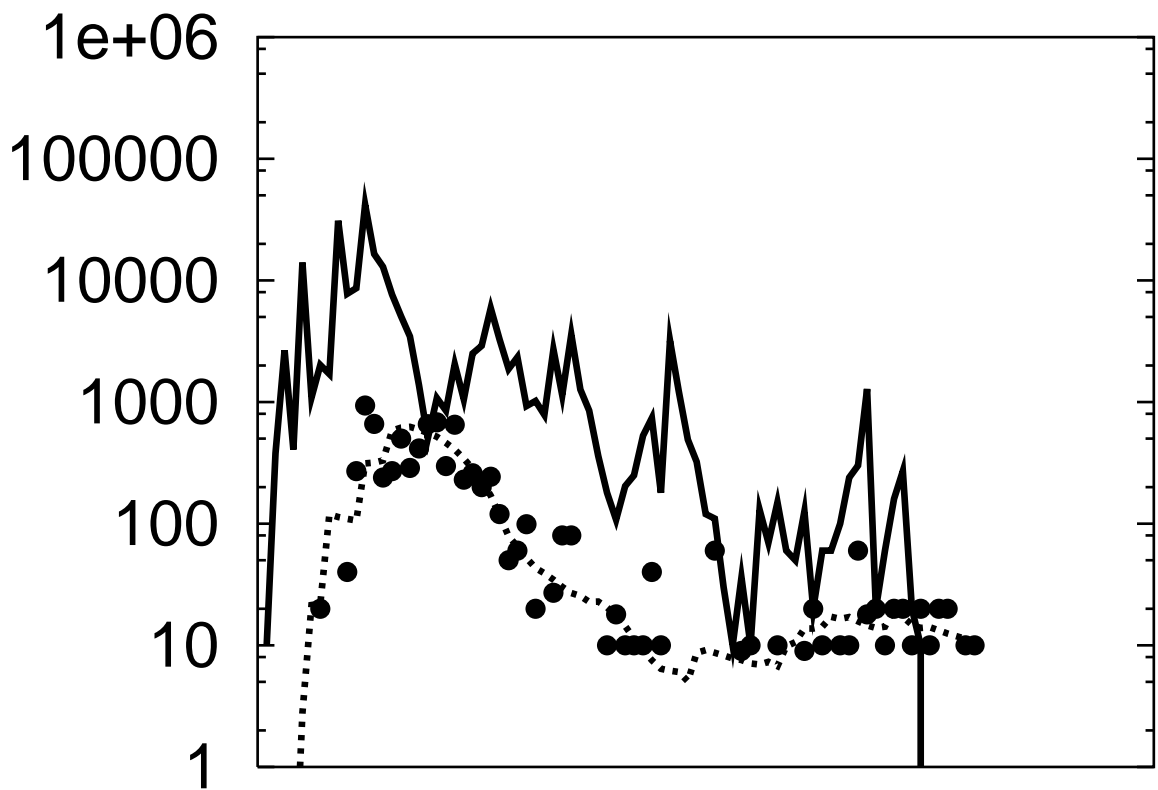
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



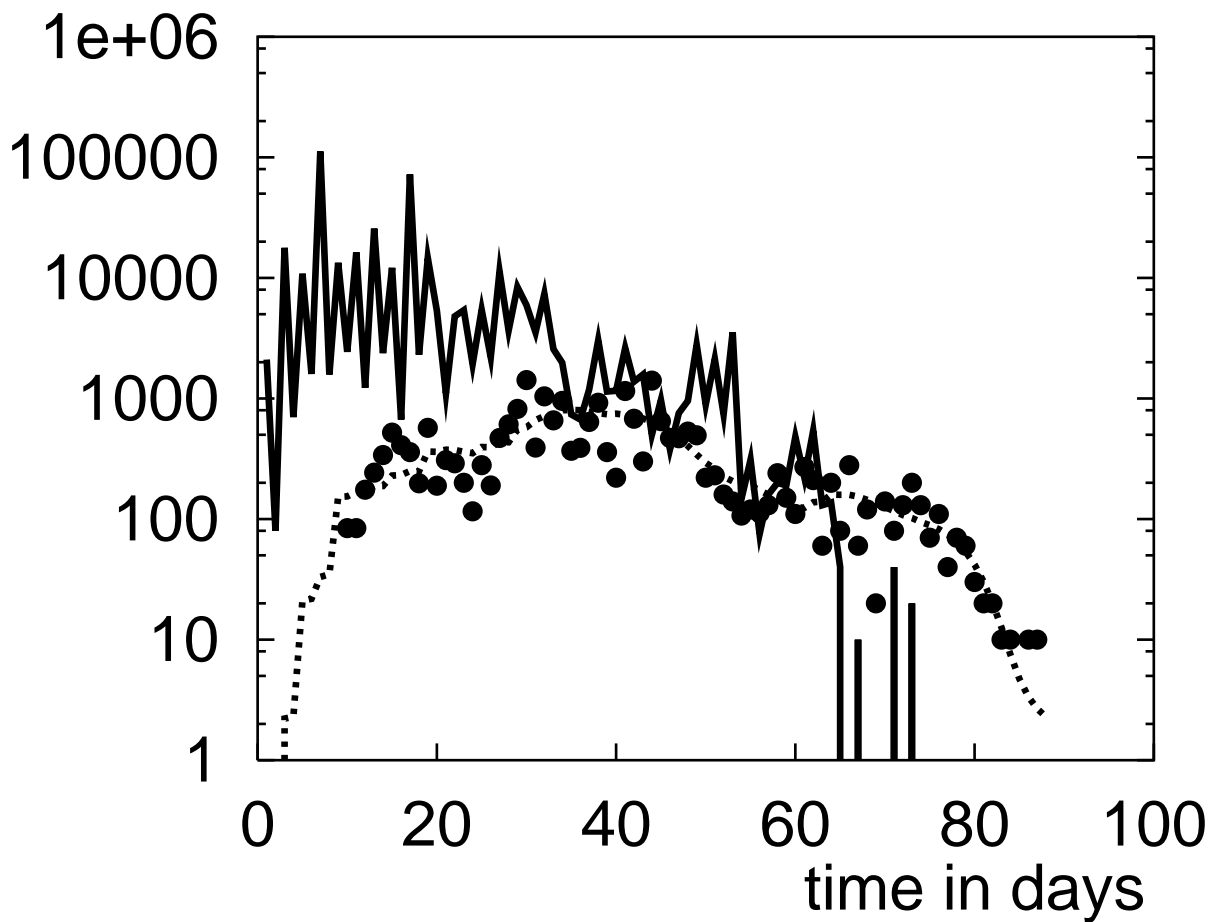
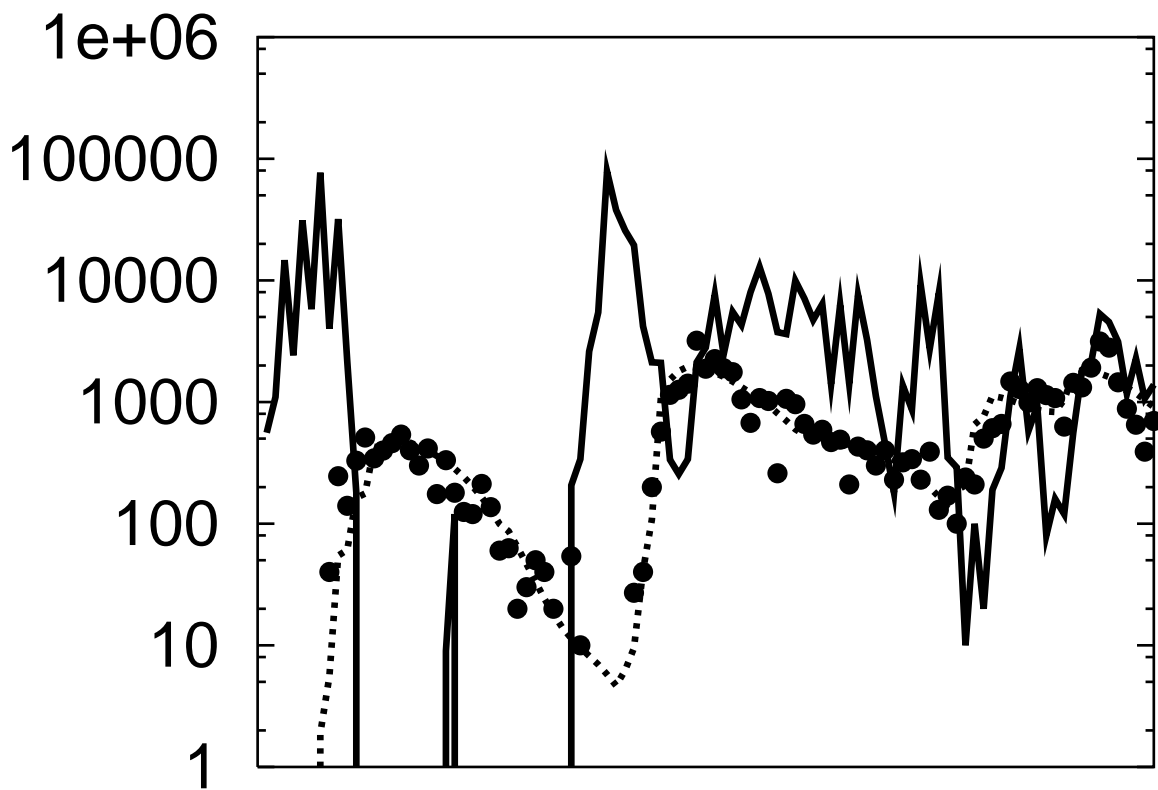
asex. parasites —
observ. gameto. •
expect gameto.

parasites per μl blood



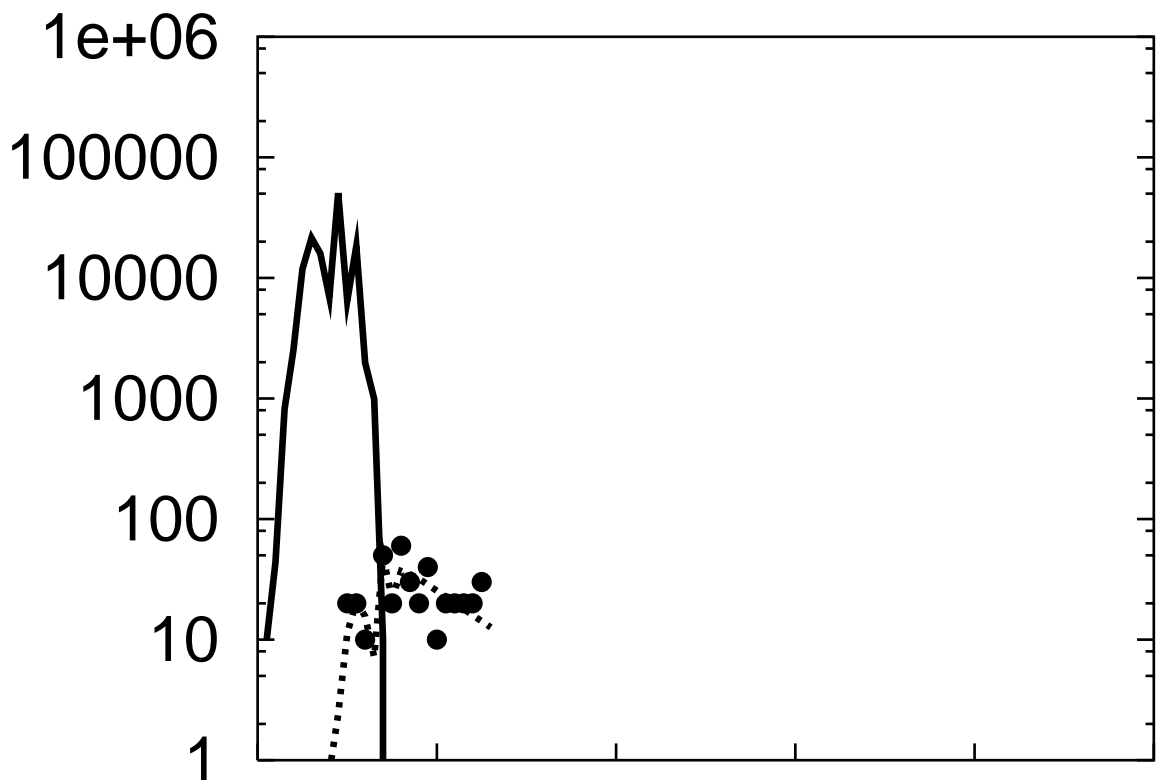
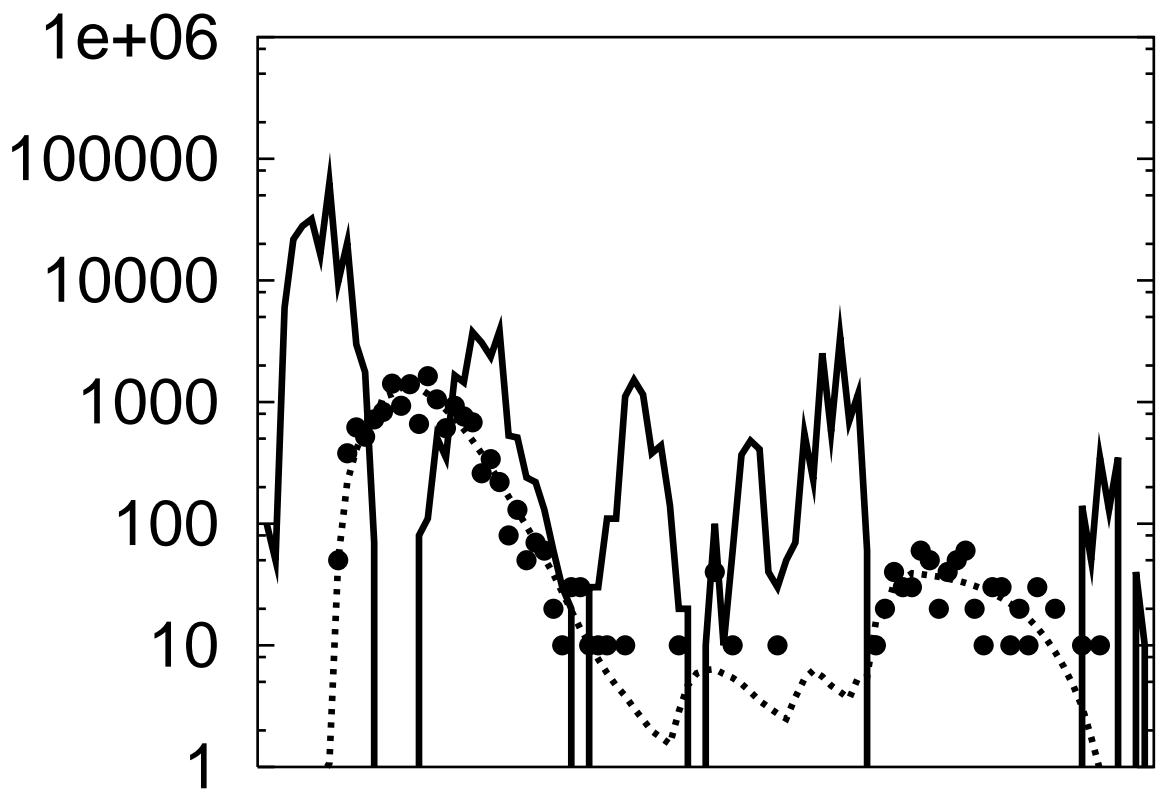
asex. parasites —————
observ. gameto. •
expect gameto. ······

parasites per μl blood



asex. parasites —
observ. gameto. •
expect gameto. ···

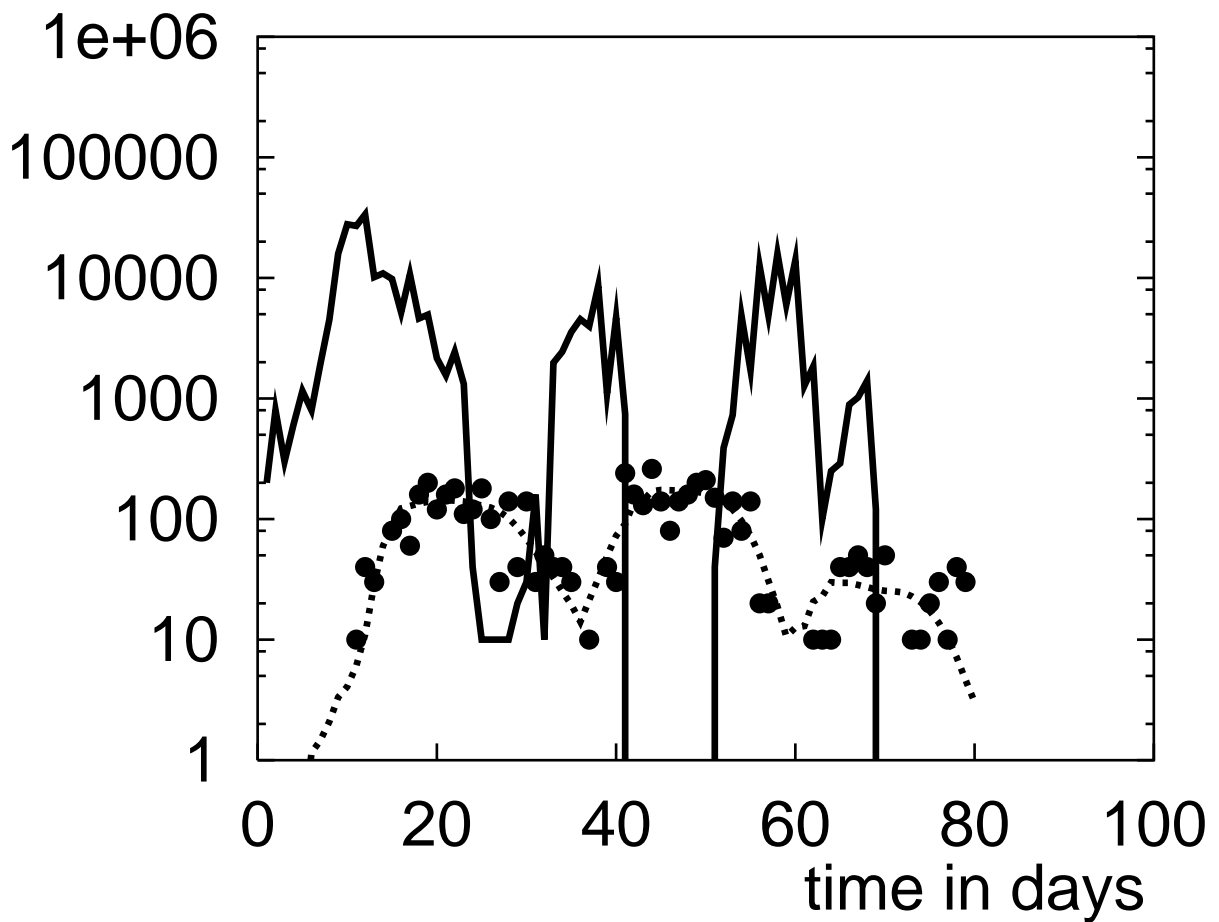
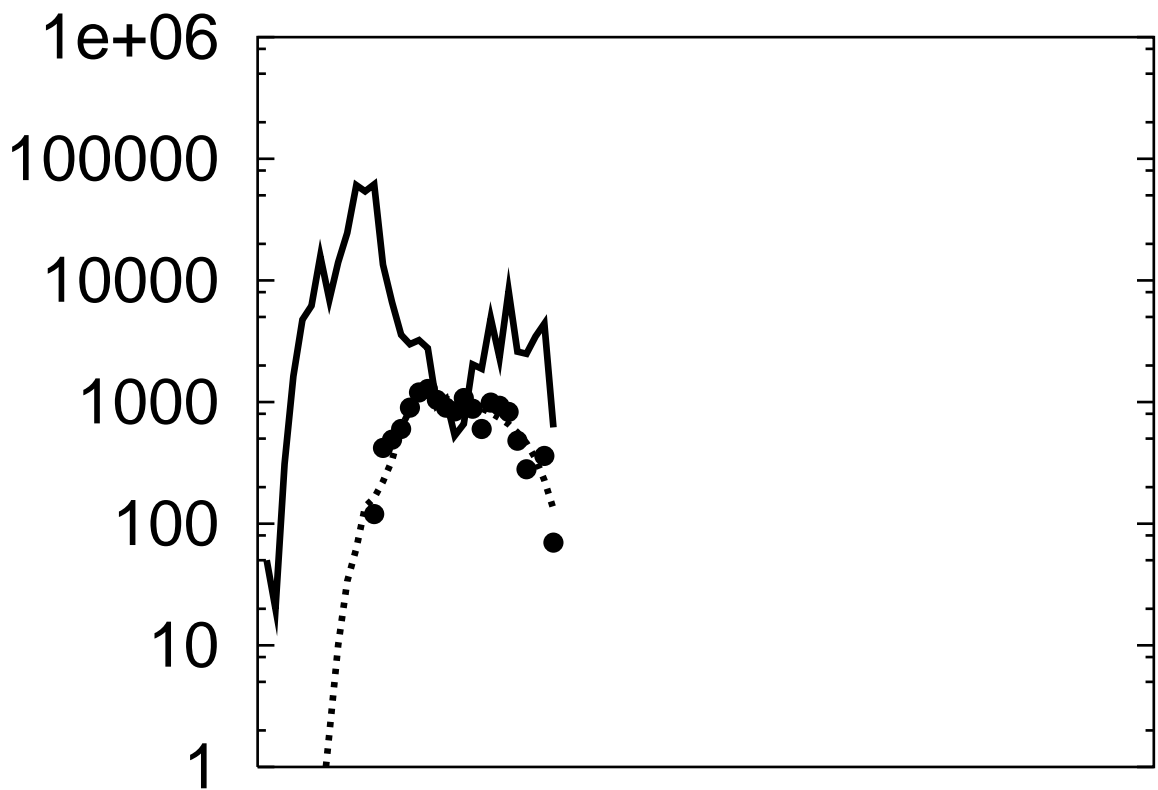
parasites per μl blood



0 20 40 60 80 100
time in days

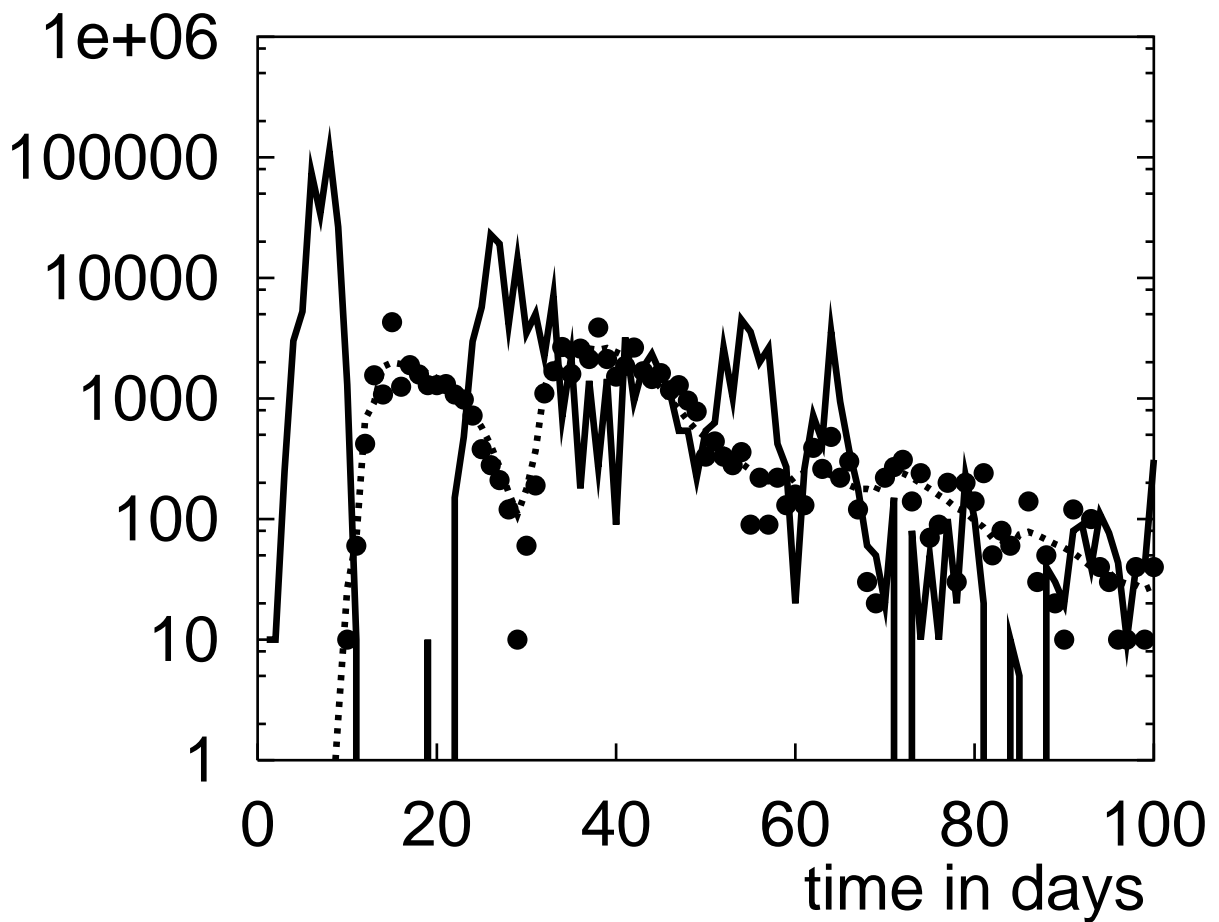
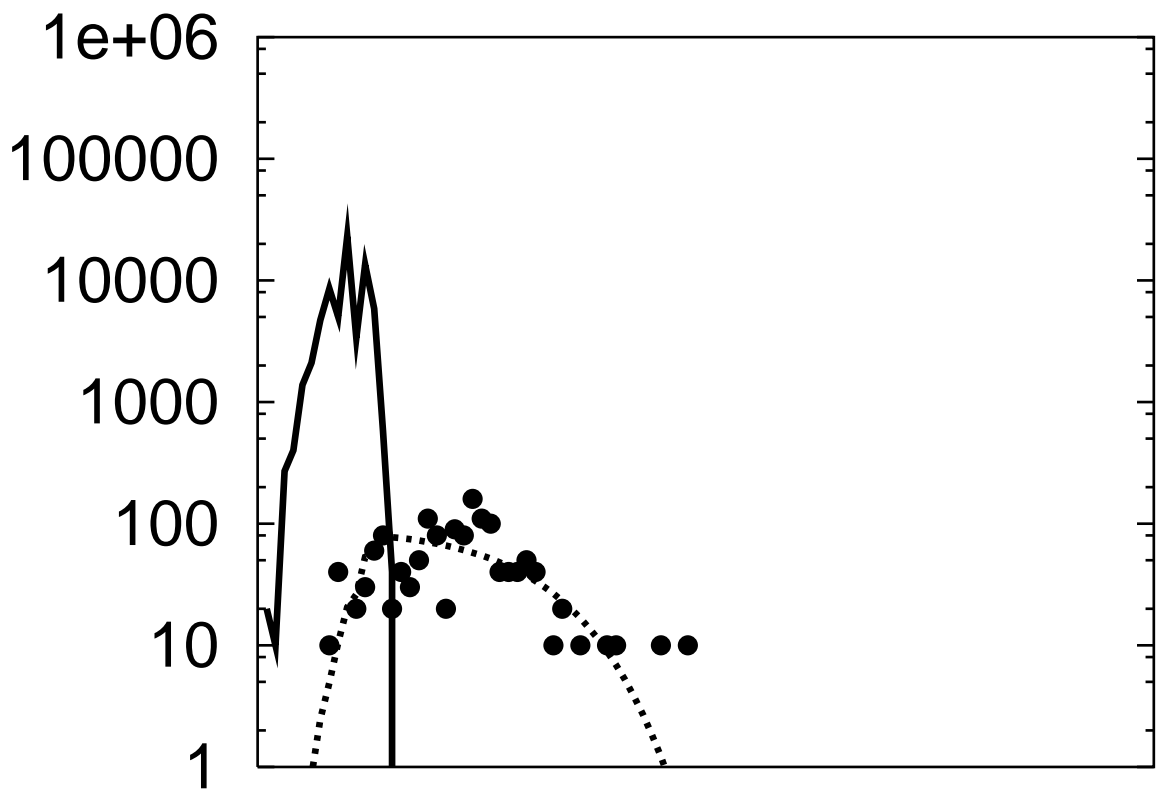
asex. parasites —
observ. gameto. •
expect gameto.

parasites per μl blood



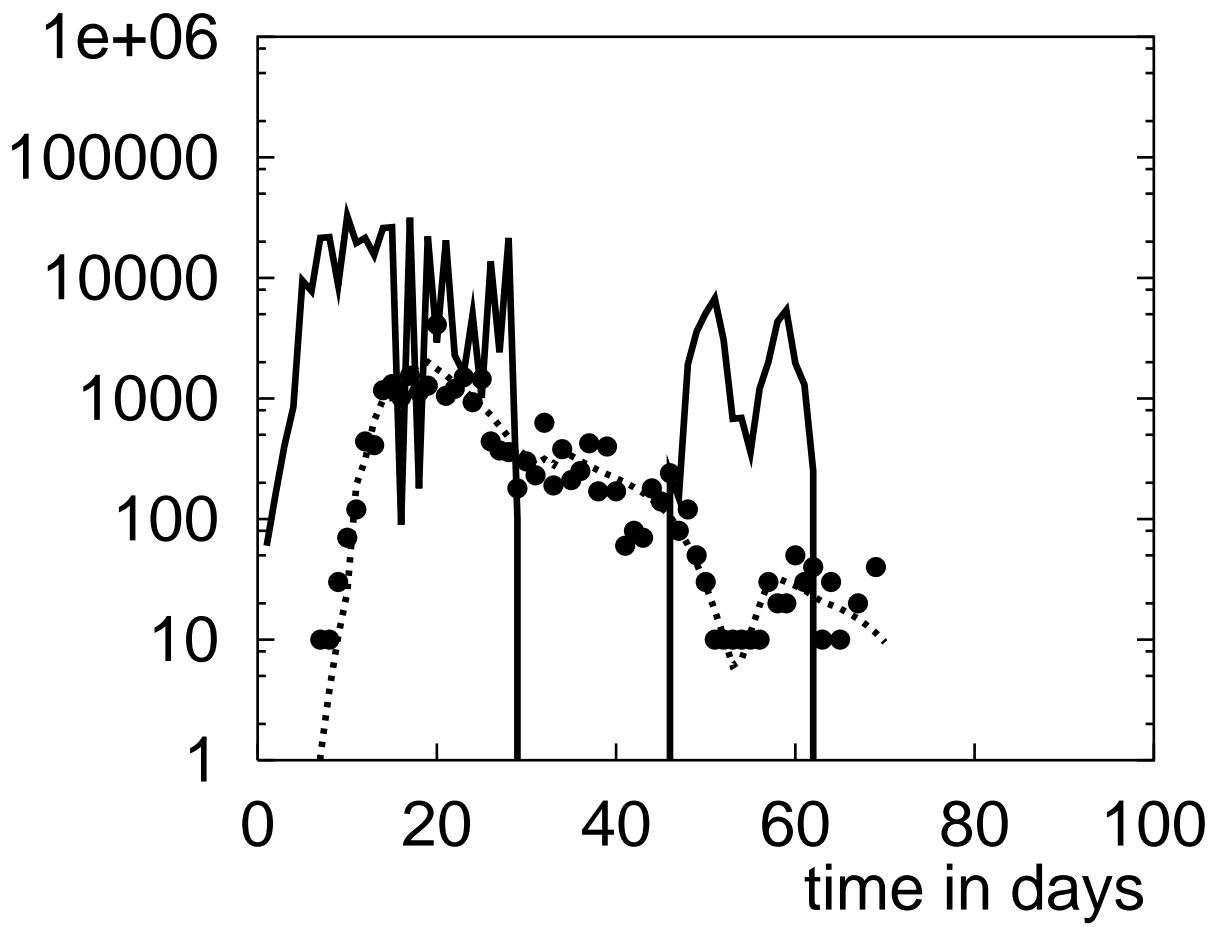
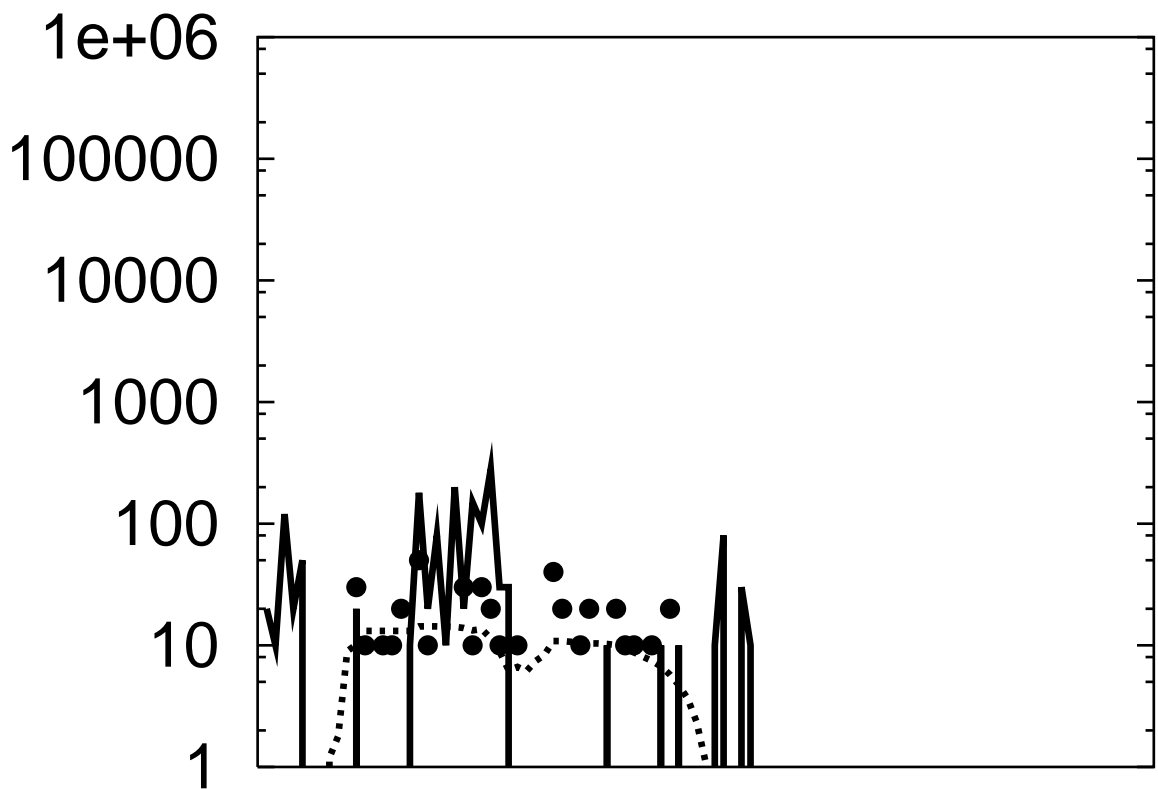
asex. parasites —
observ. gameto. •
expect gameto. ·····

parasites per μl blood



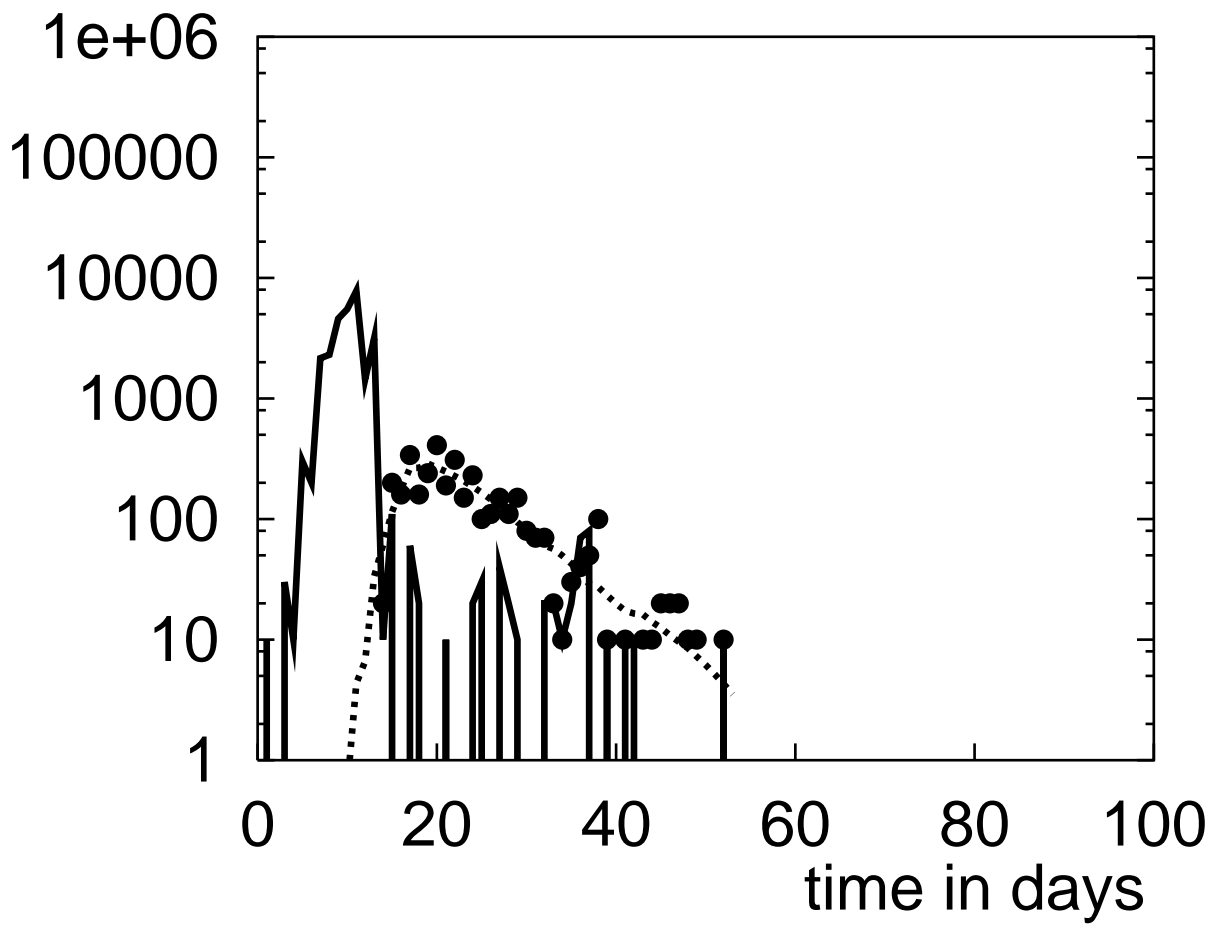
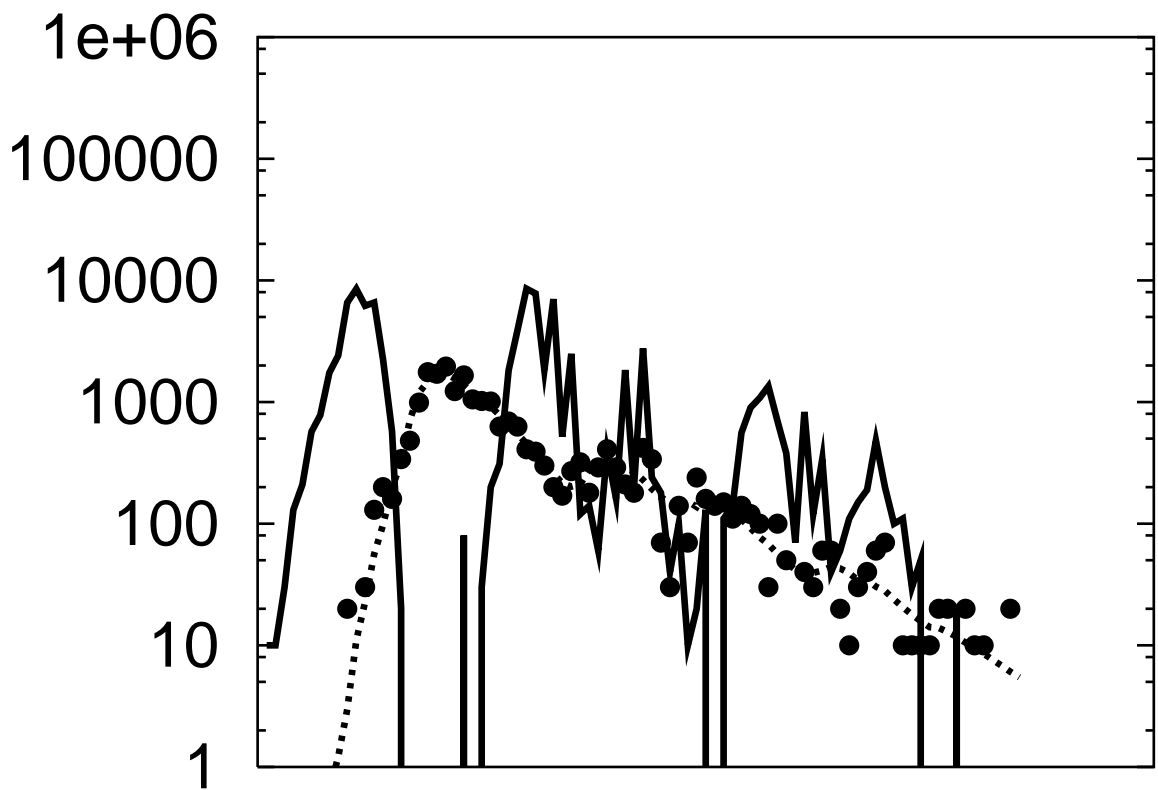
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



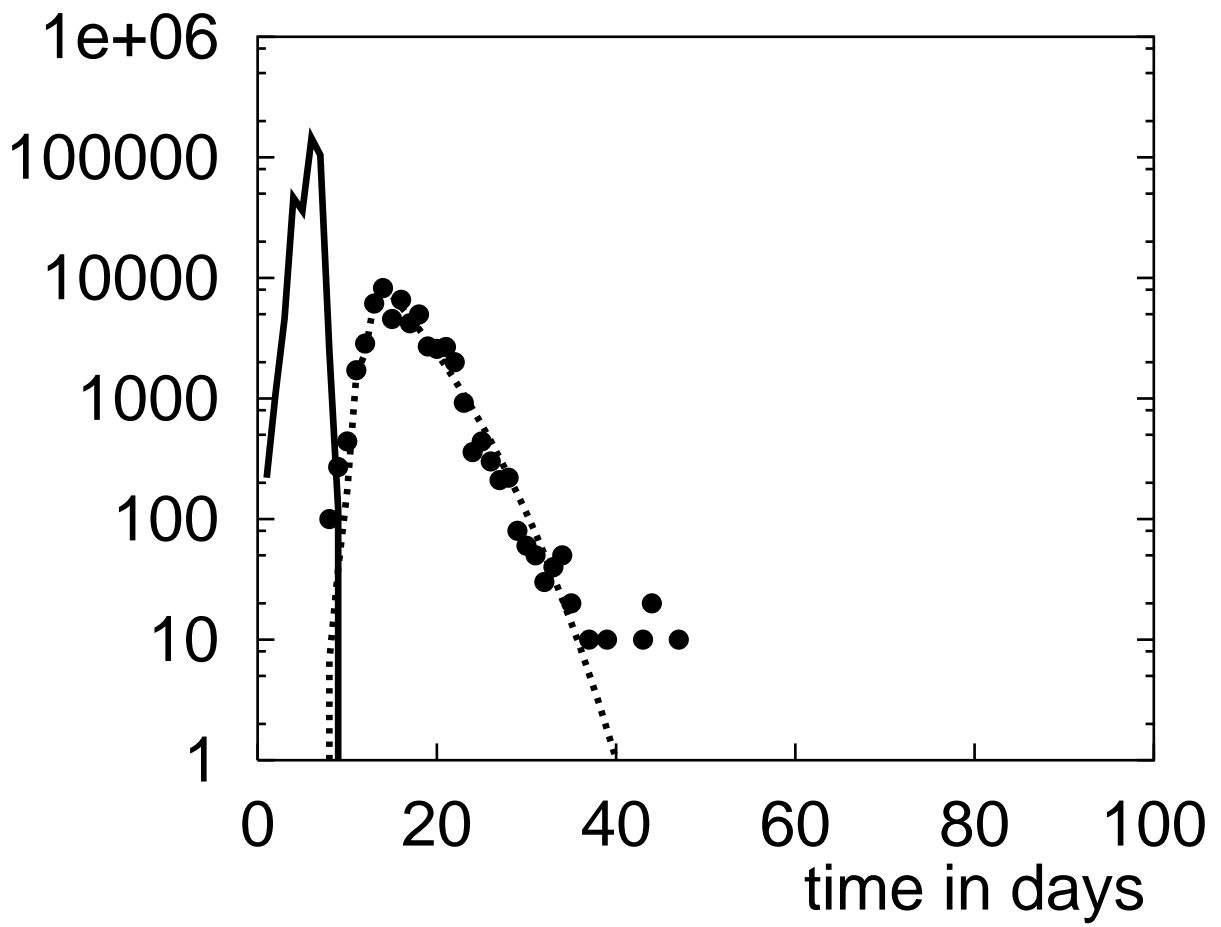
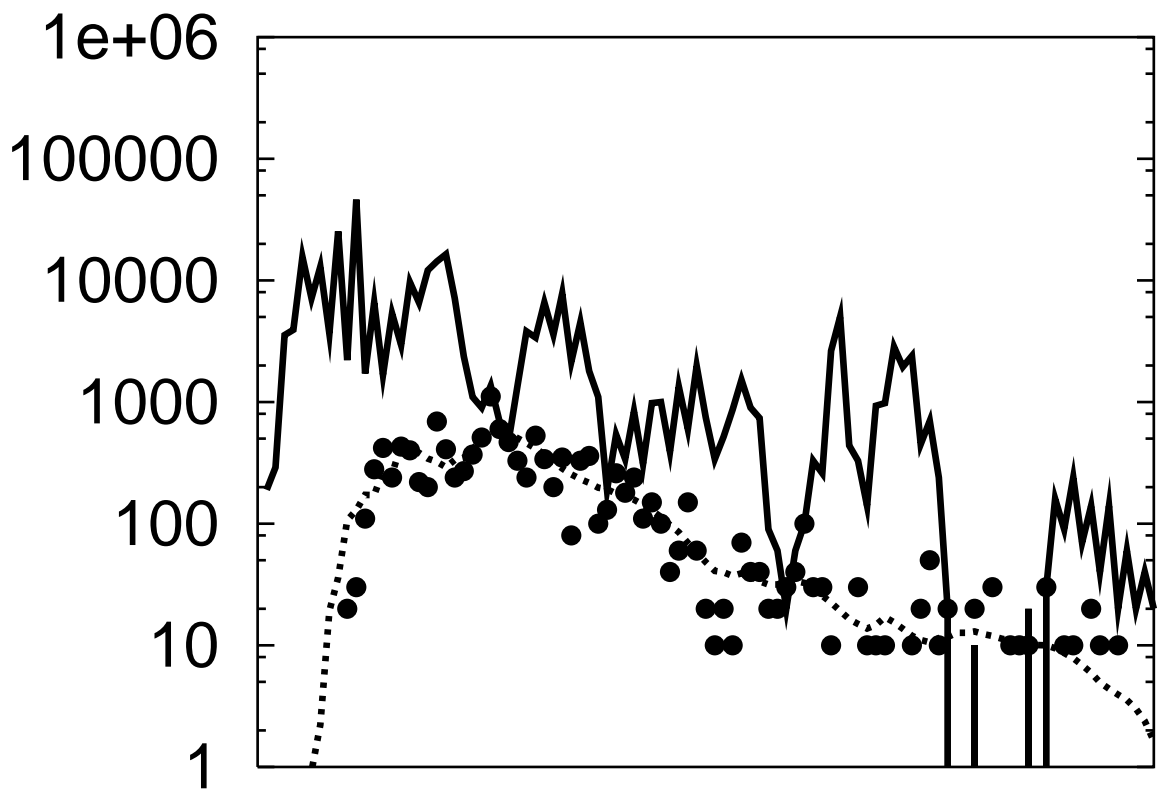
asex. parasites —
observ. gameto. •
expect gameto. ·····

parasites per μl blood



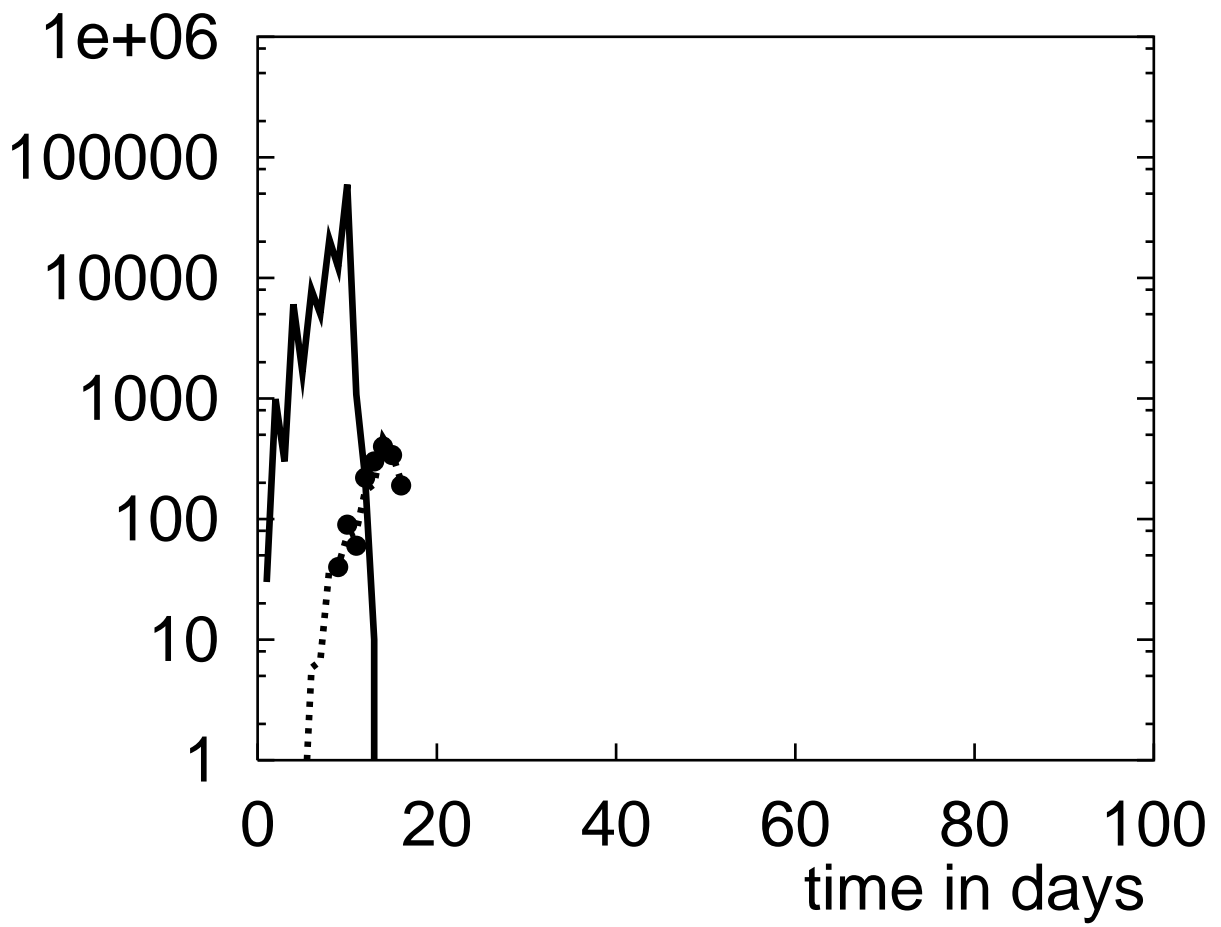
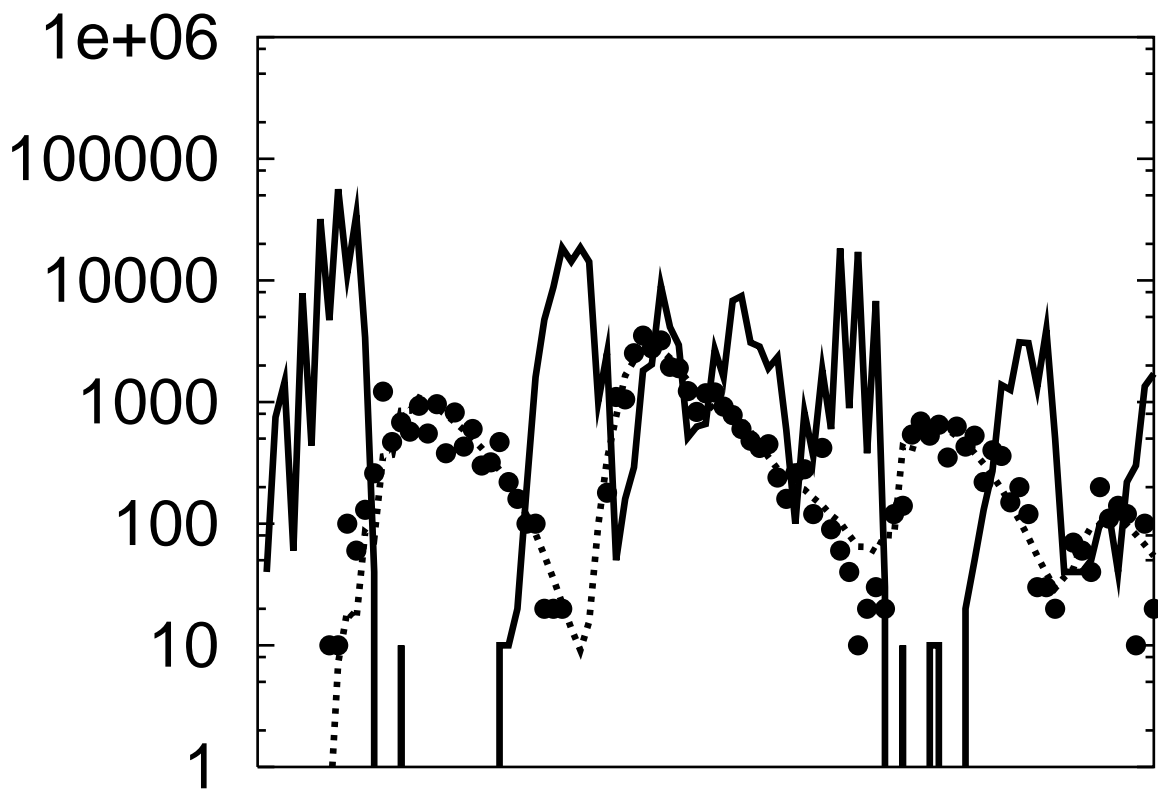
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



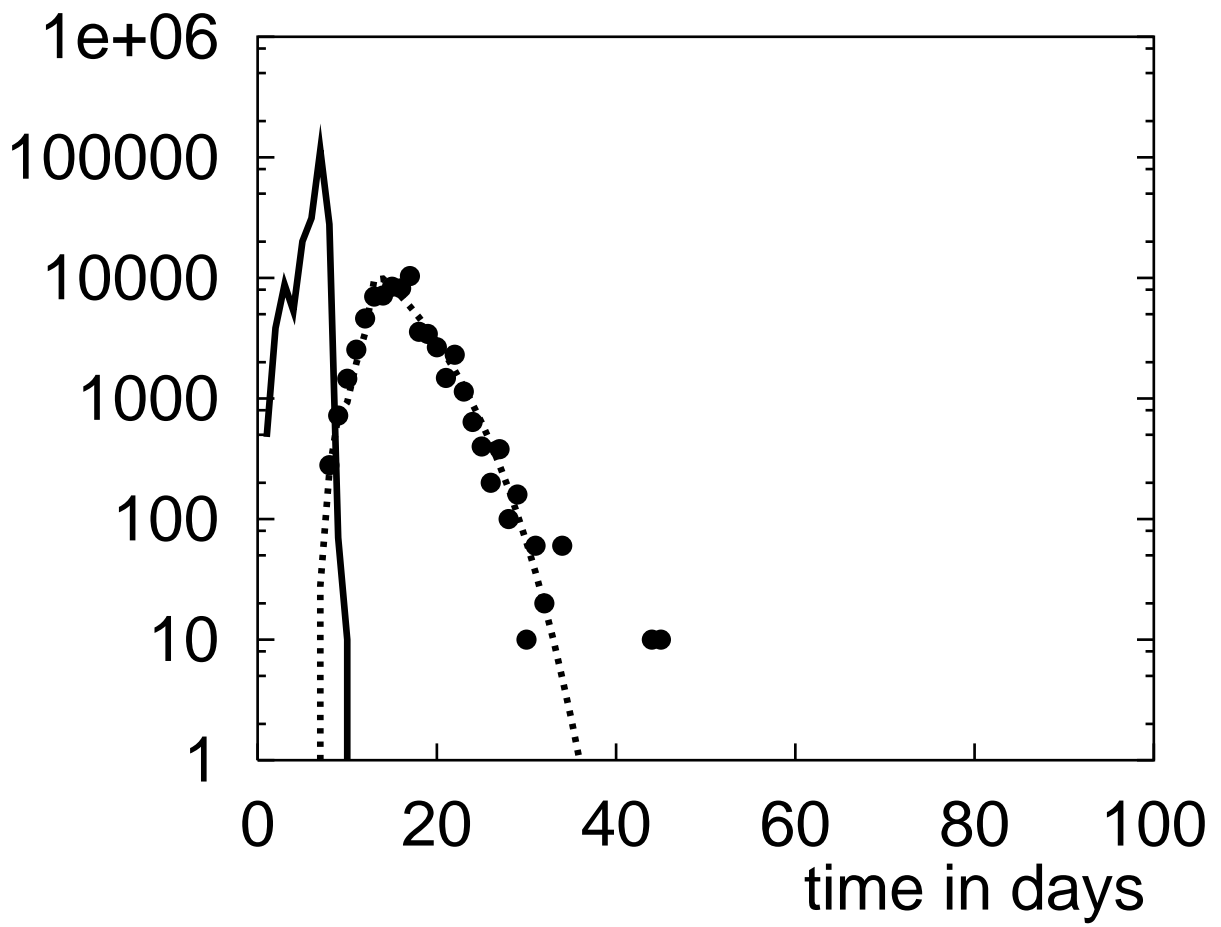
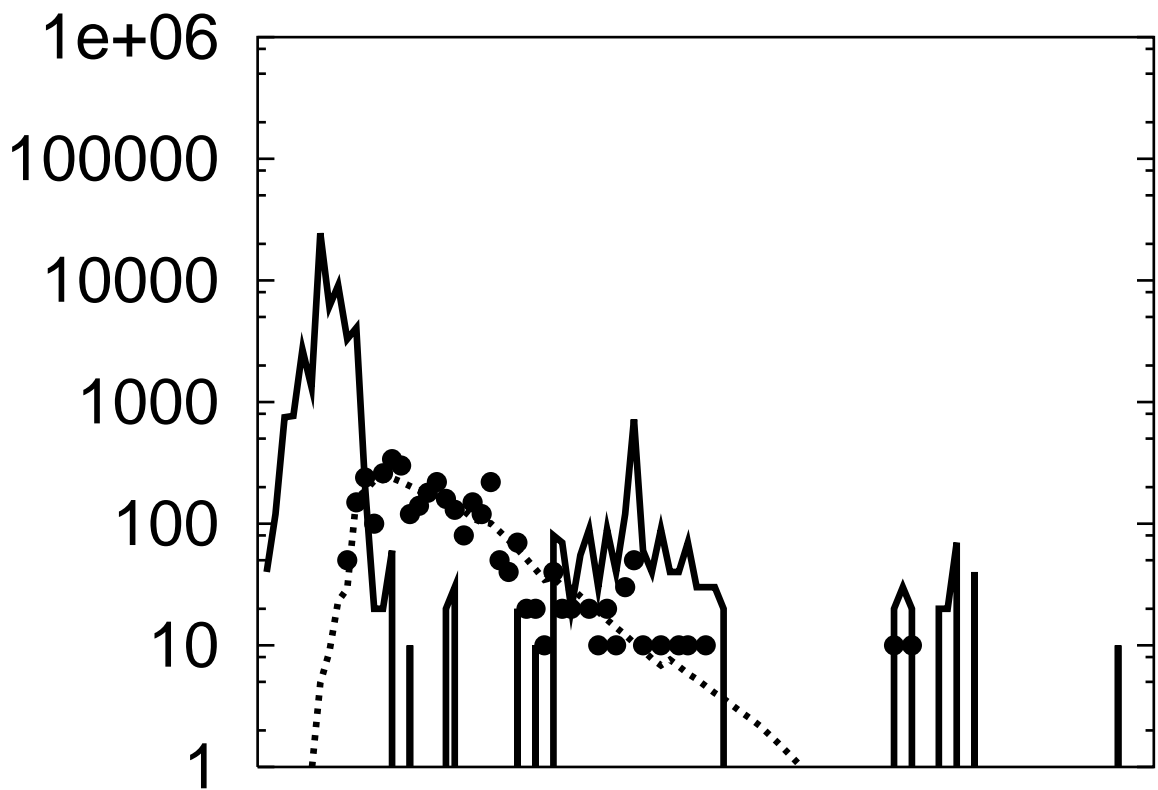
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



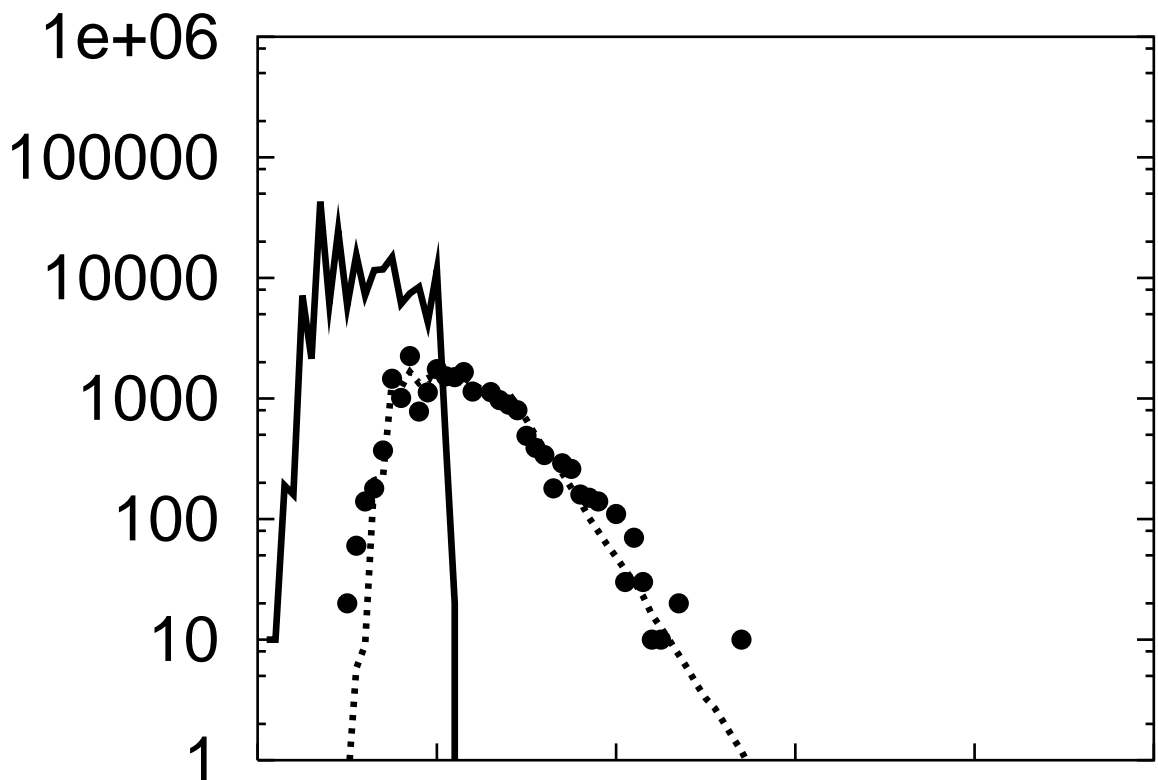
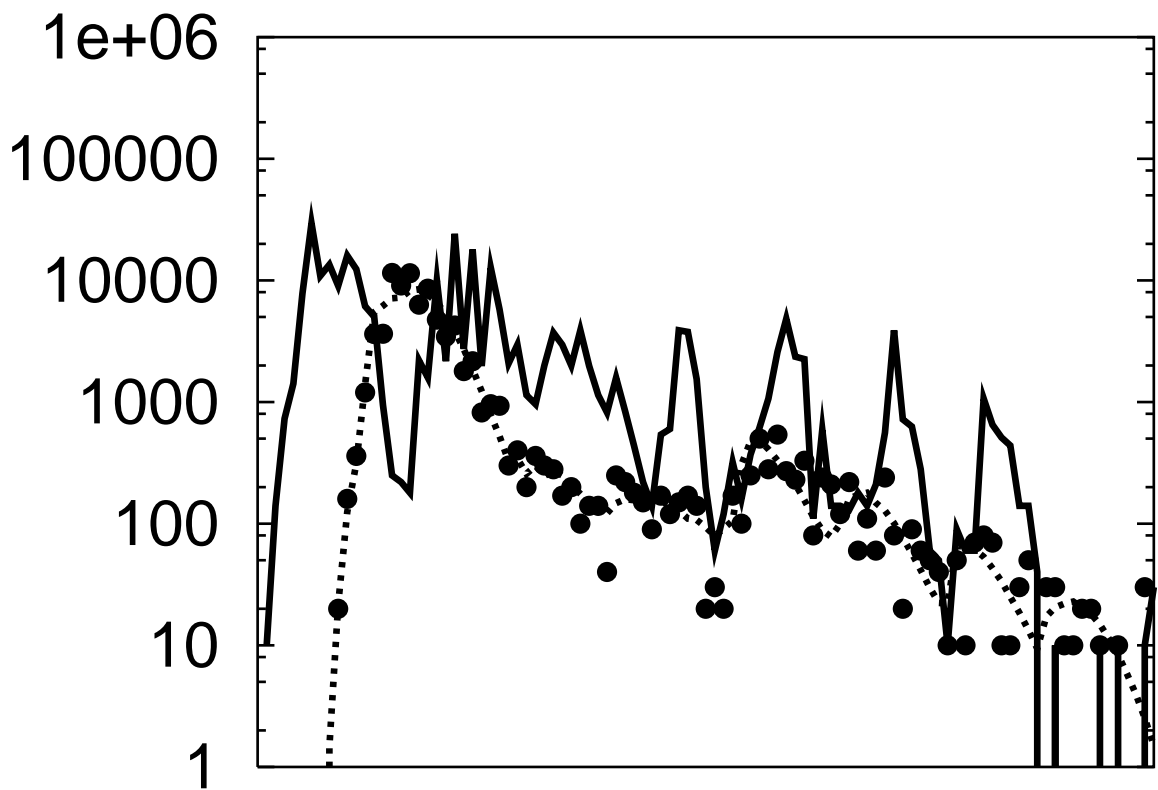
asex. parasites —
observ. gameto. •
expect gameto. ·····

parasites per μl blood



asex. parasites ———
observ. gameto. •
expect gameto. ·····

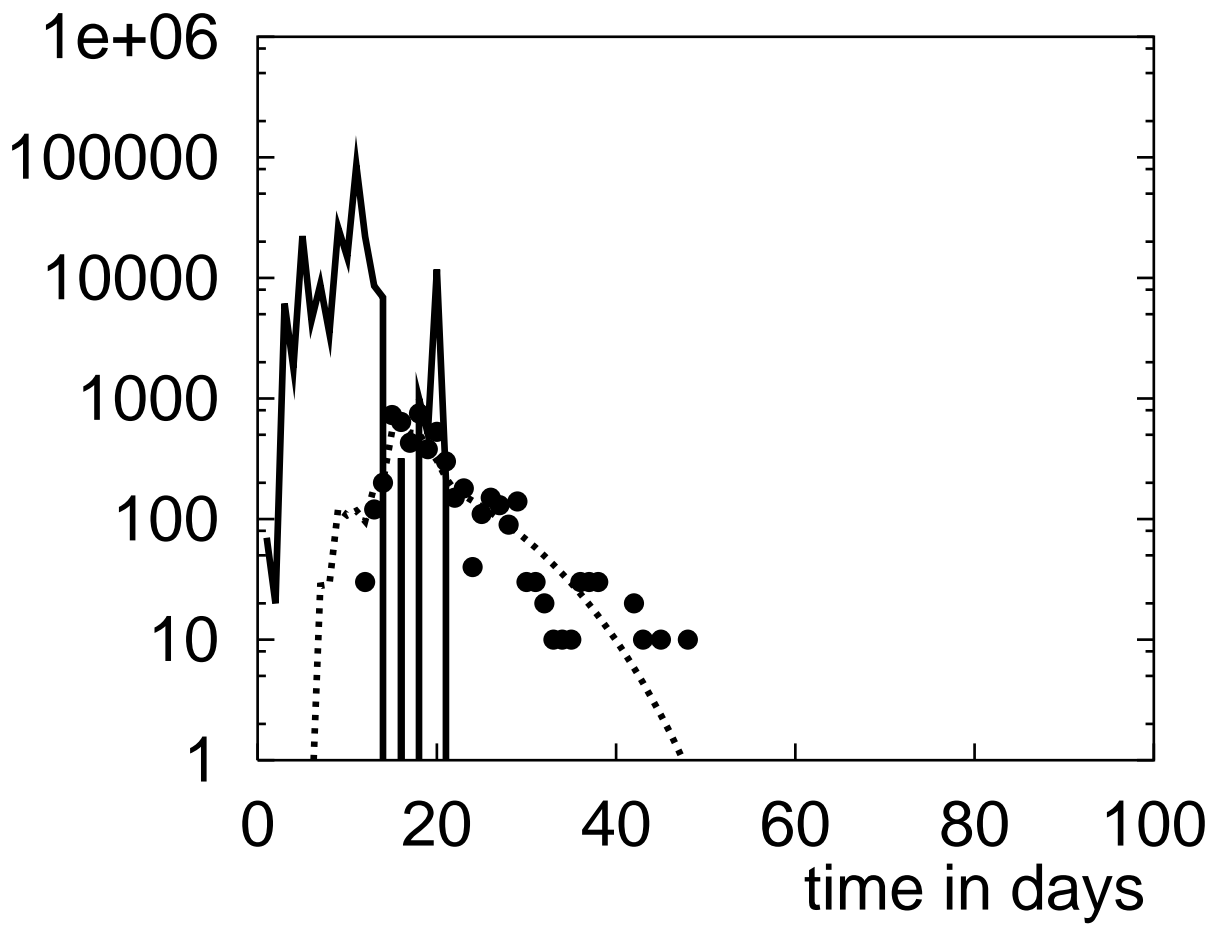
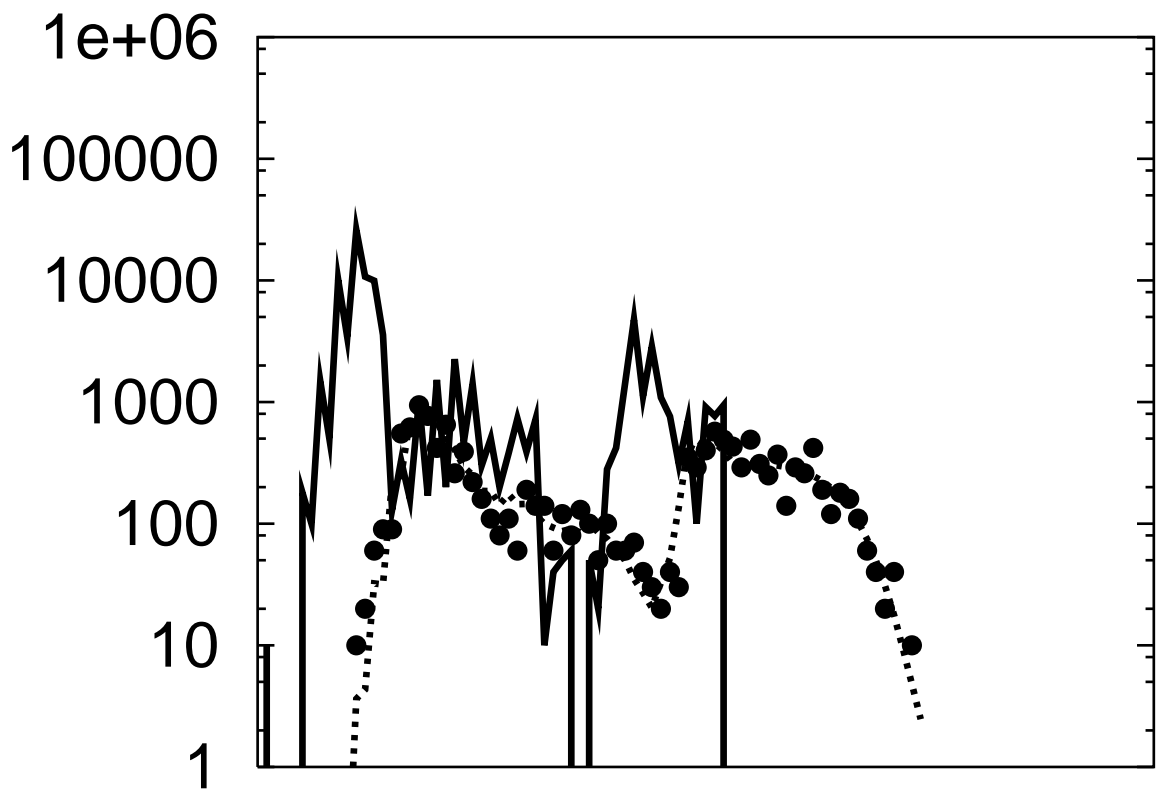
parasites per μl blood



0 20 40 60 80 100
time in days

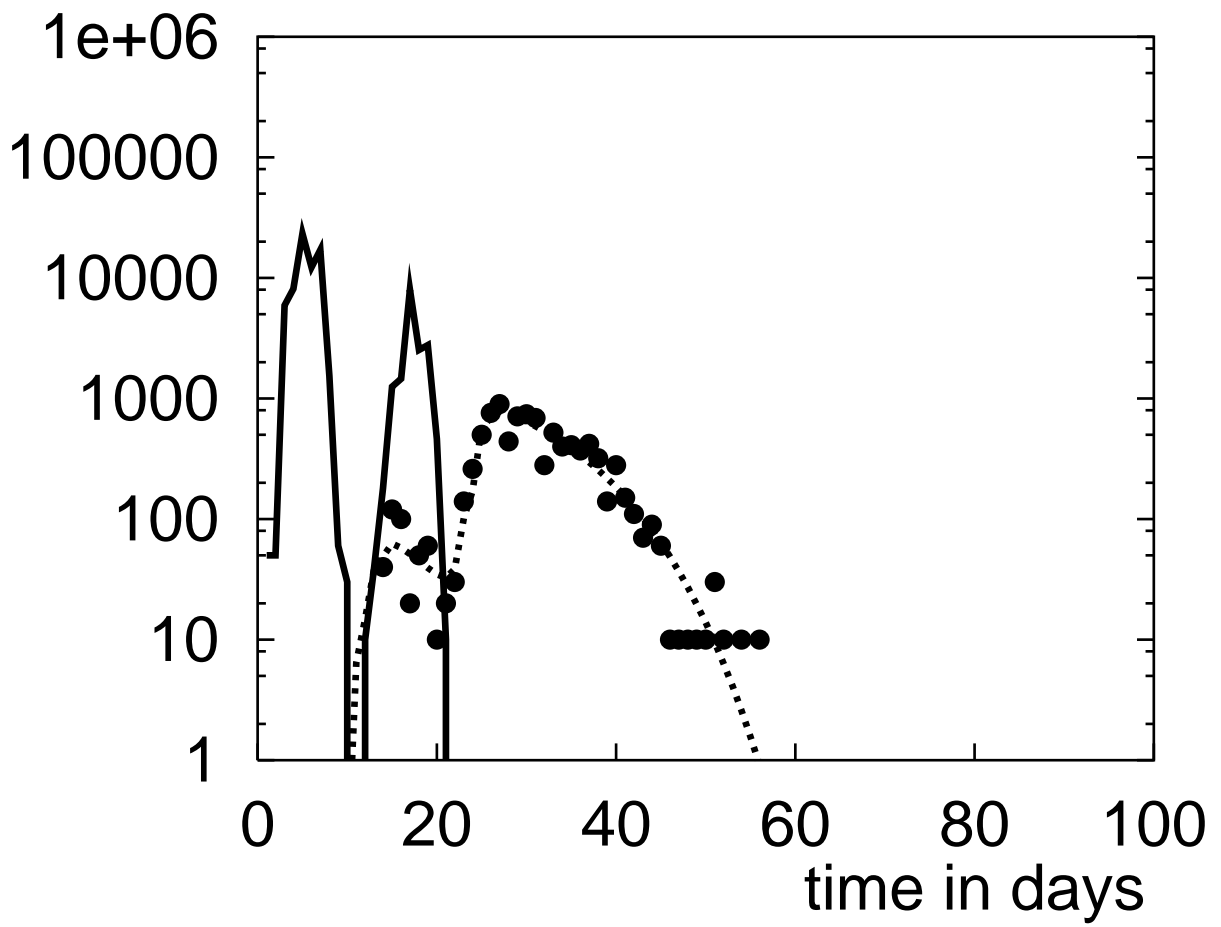
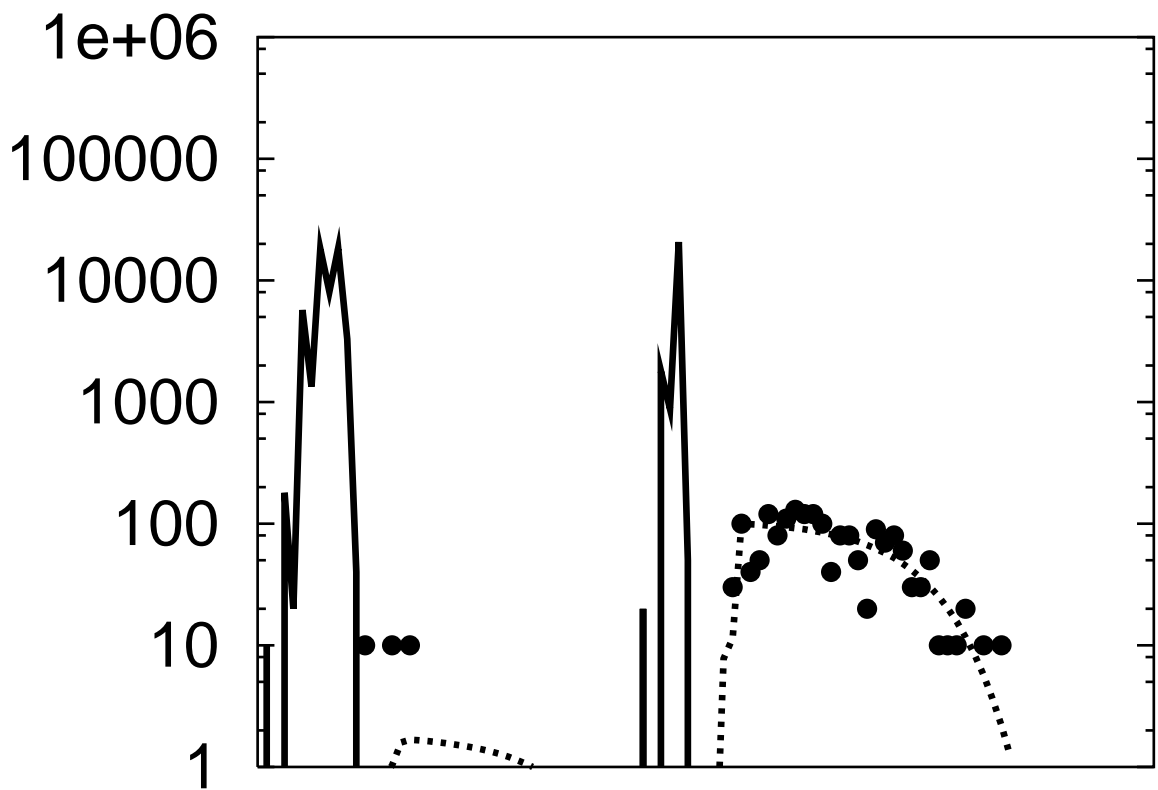
asex. parasites —
observ. gameto. •
expect gameto. ···

parasites per μl blood



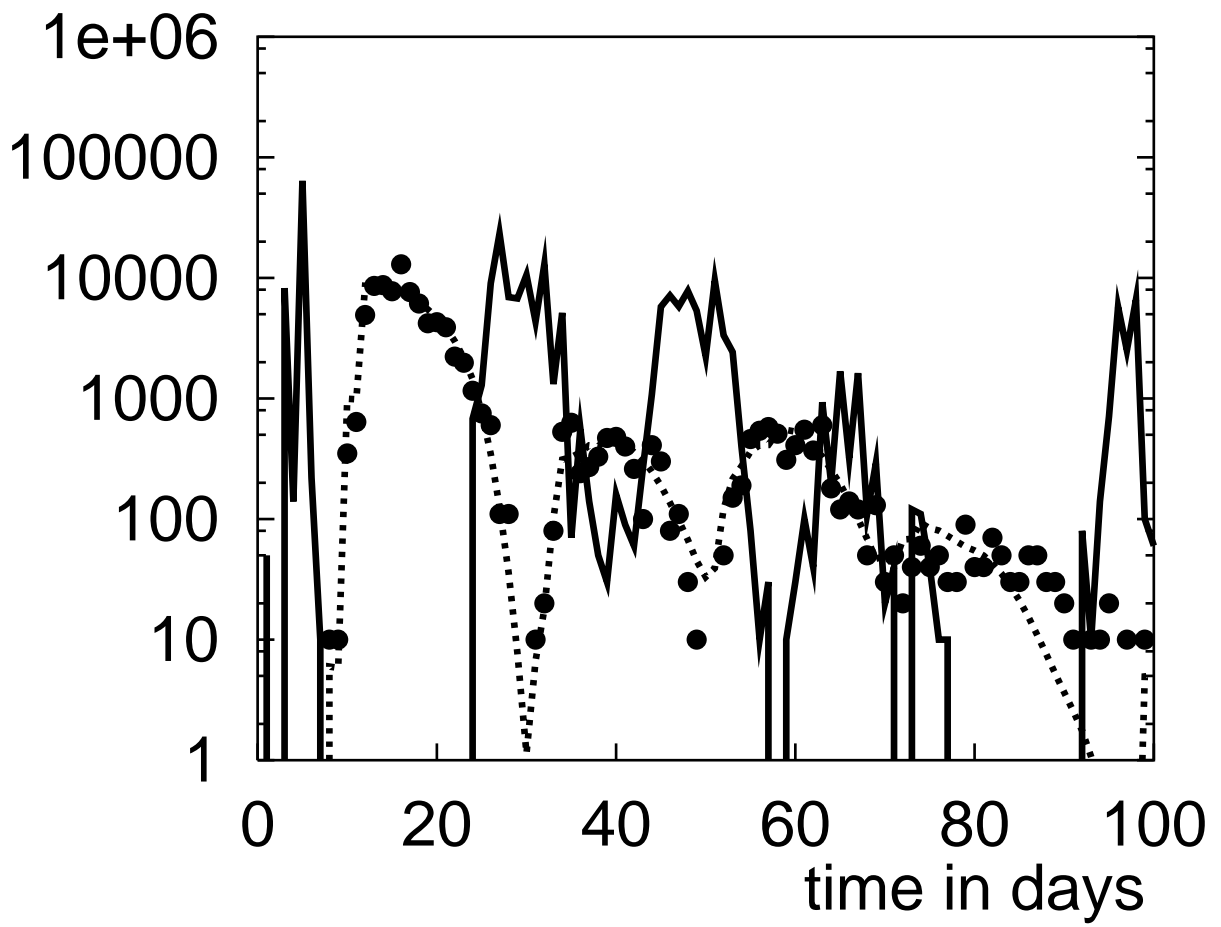
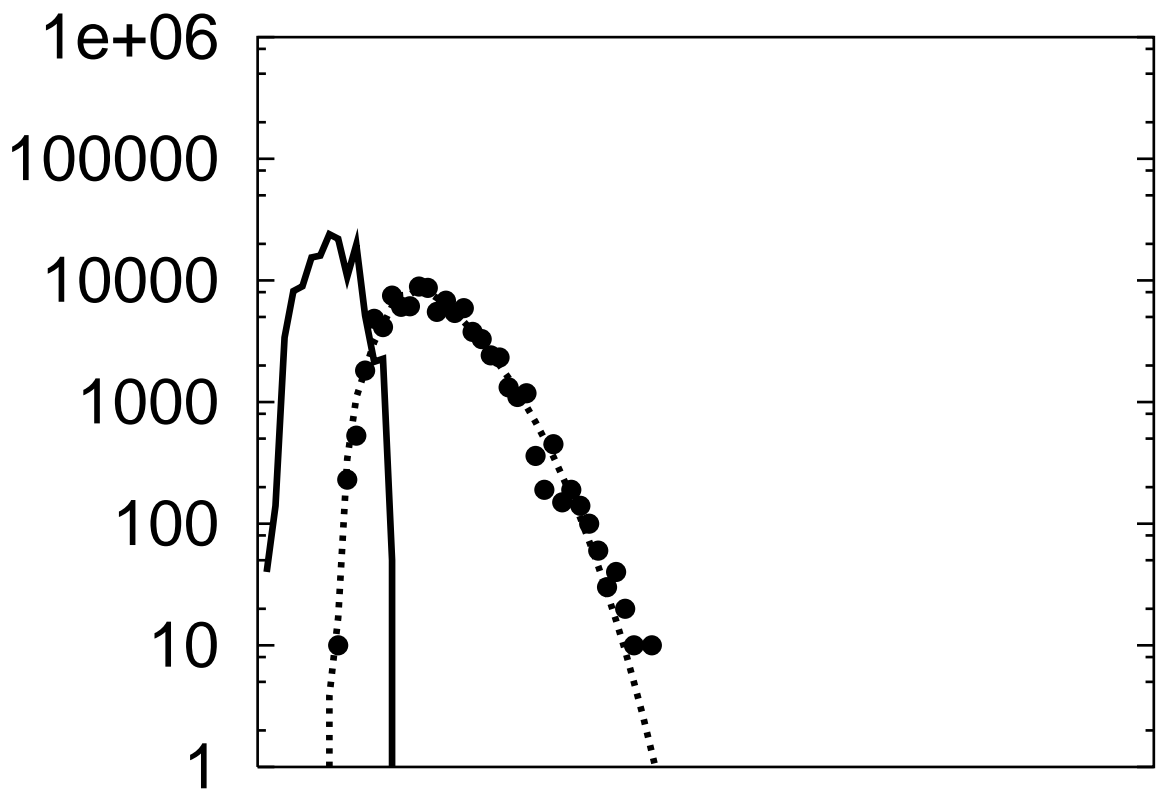
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



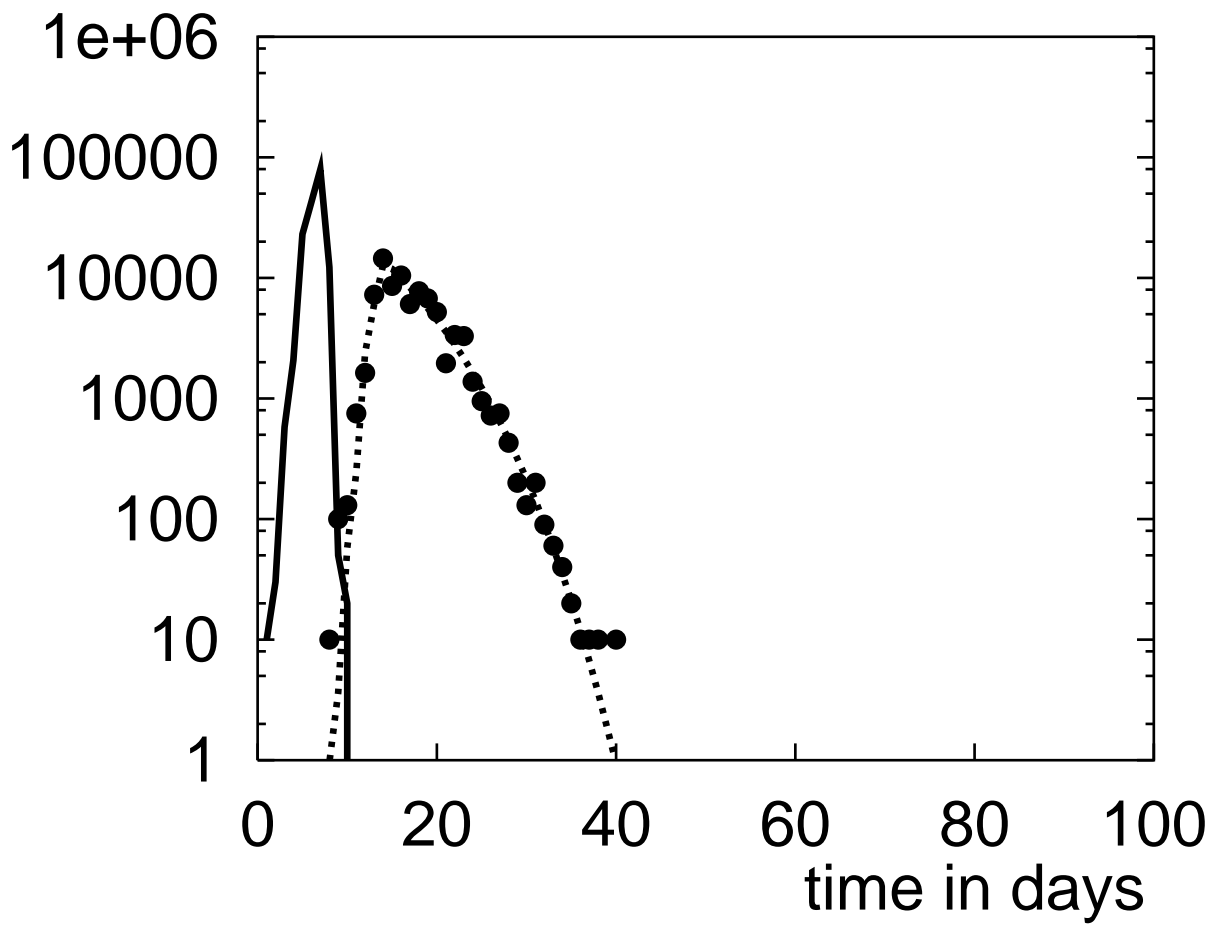
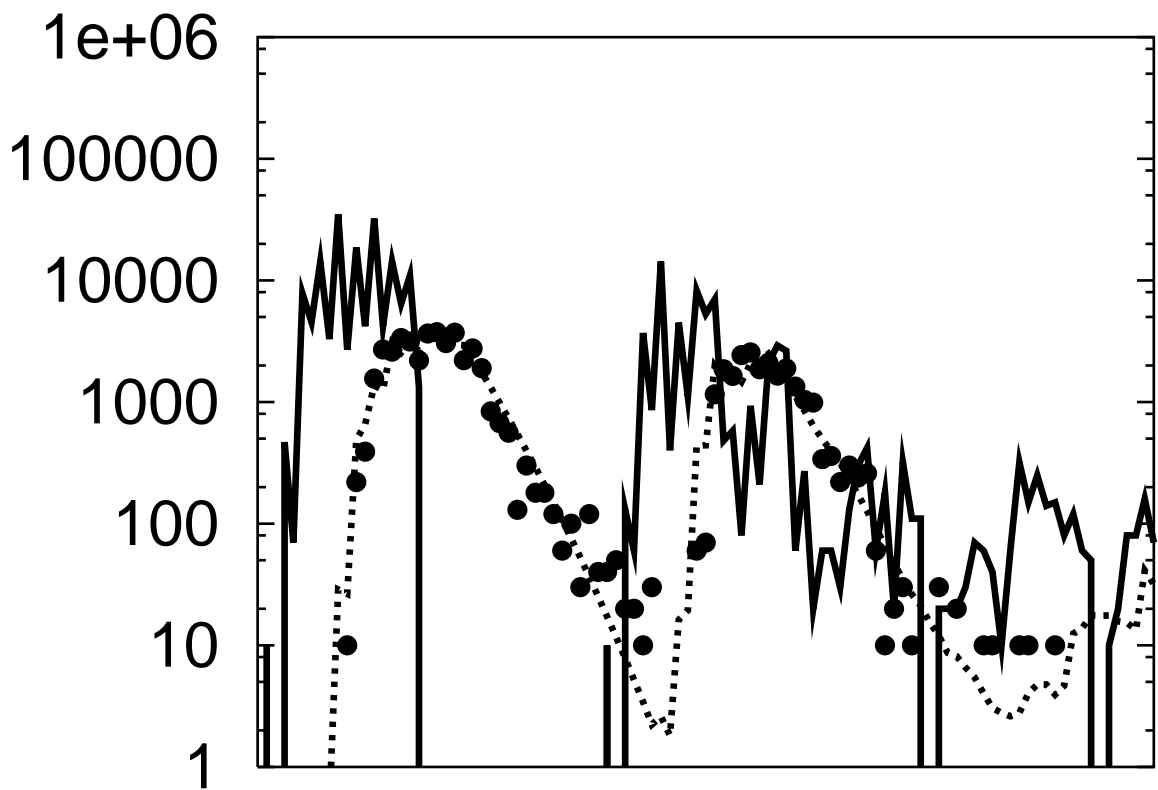
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



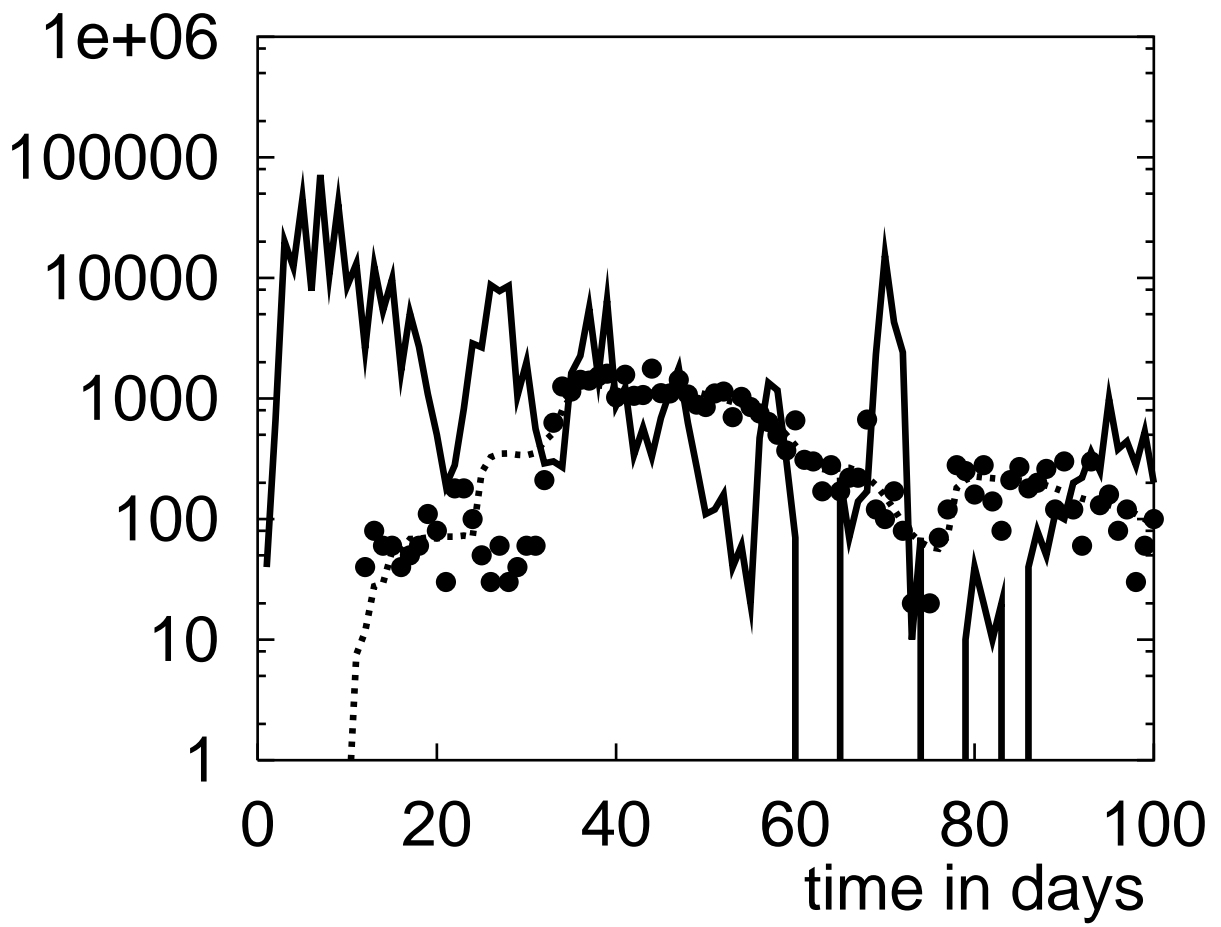
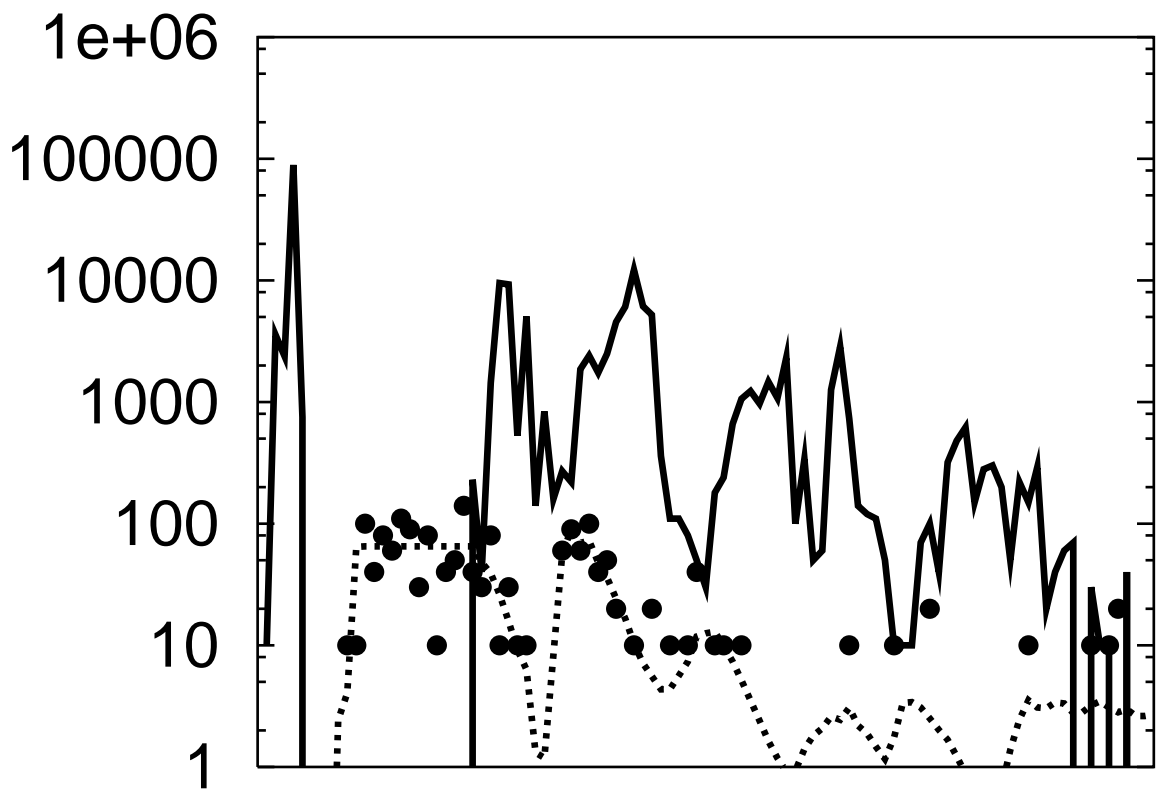
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



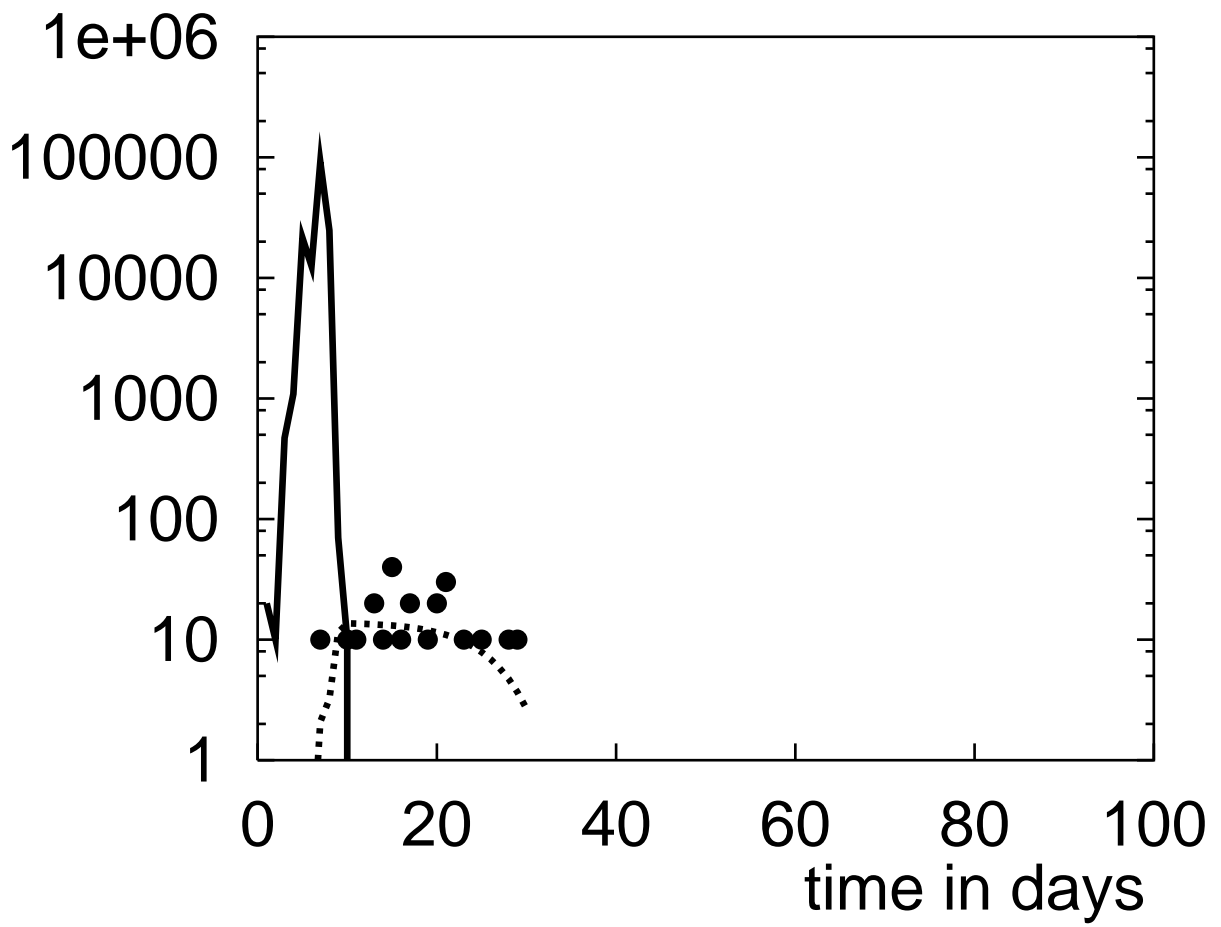
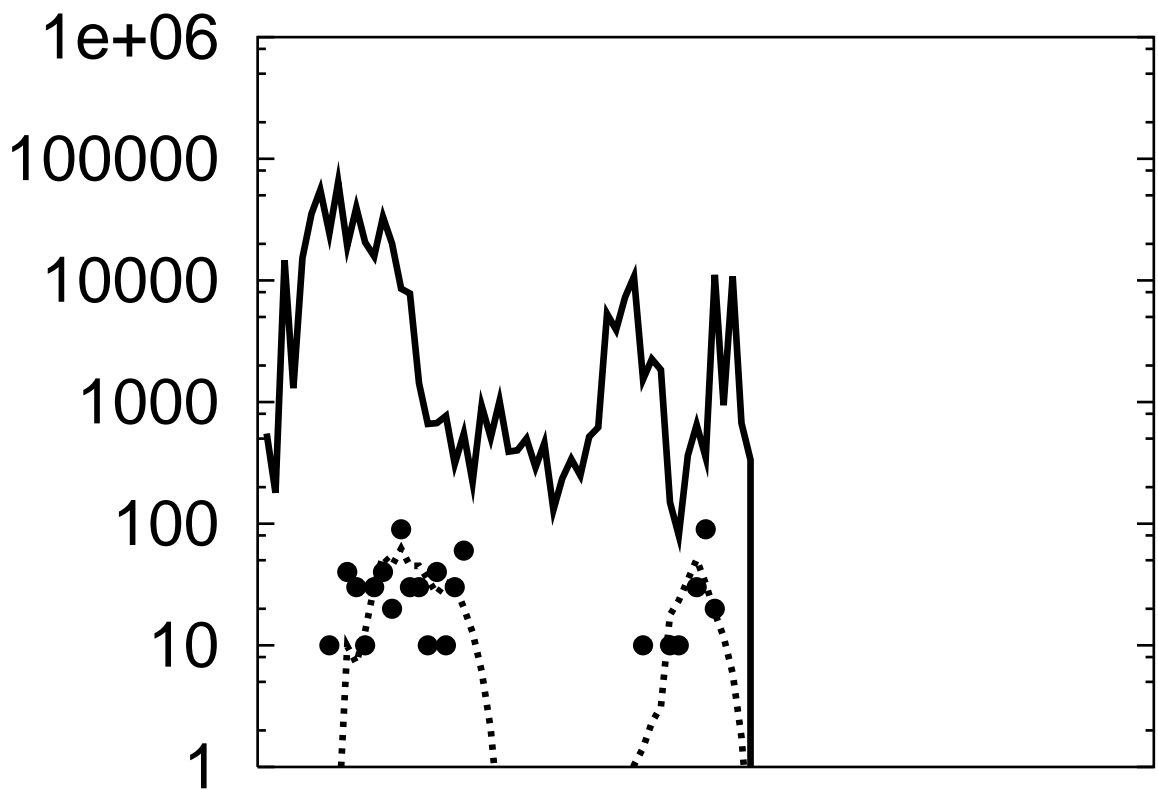
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



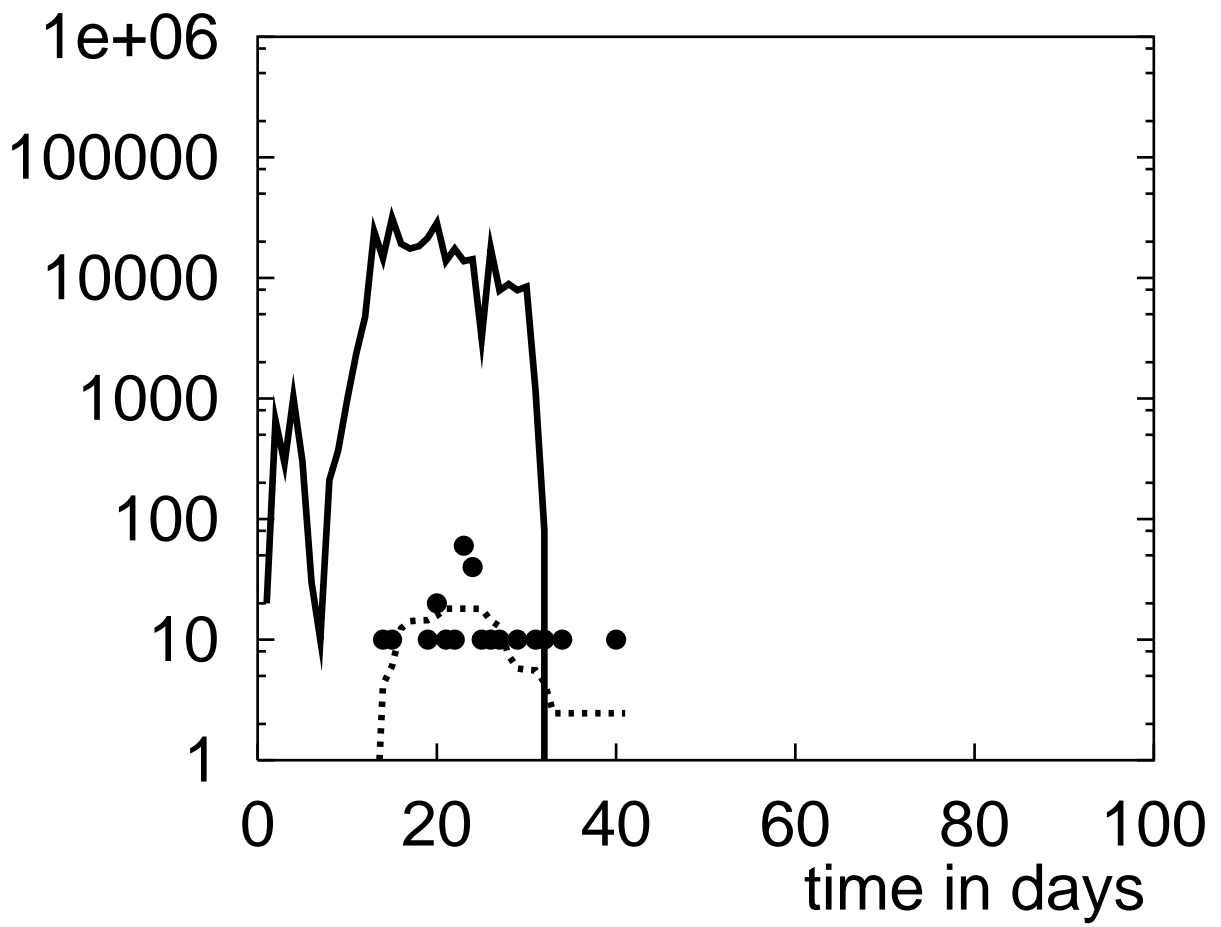
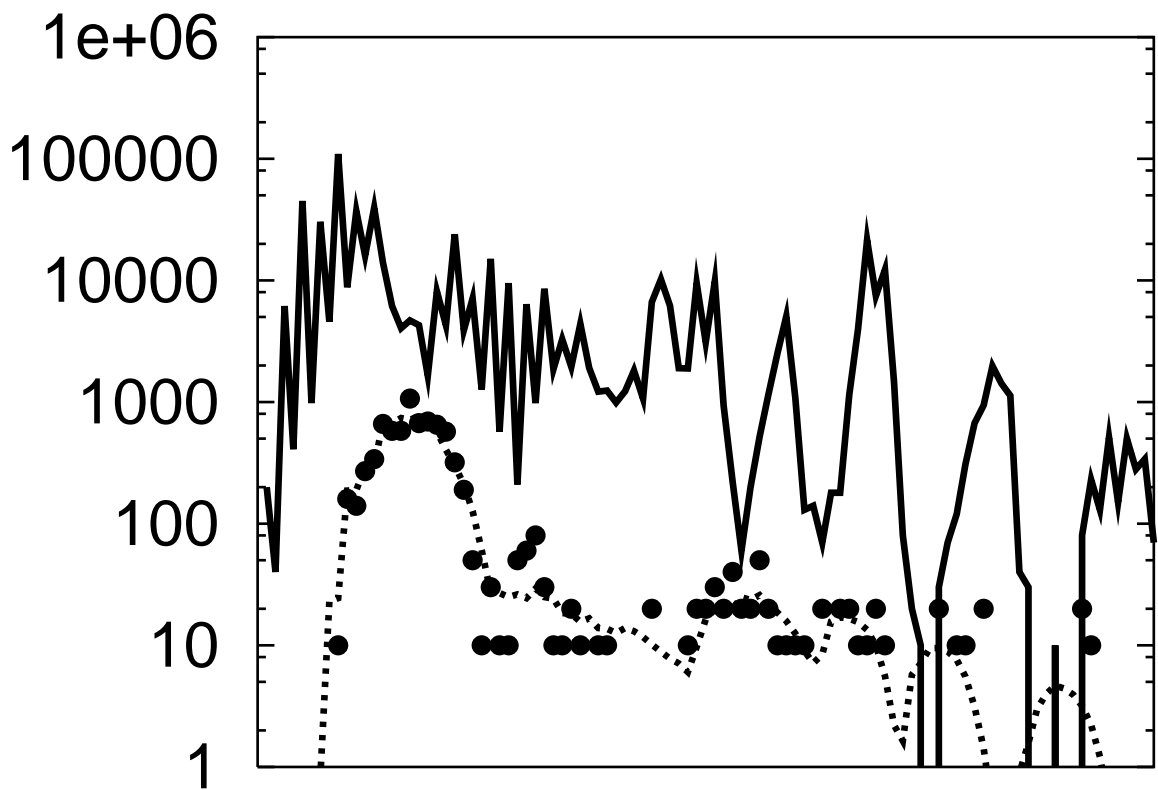
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



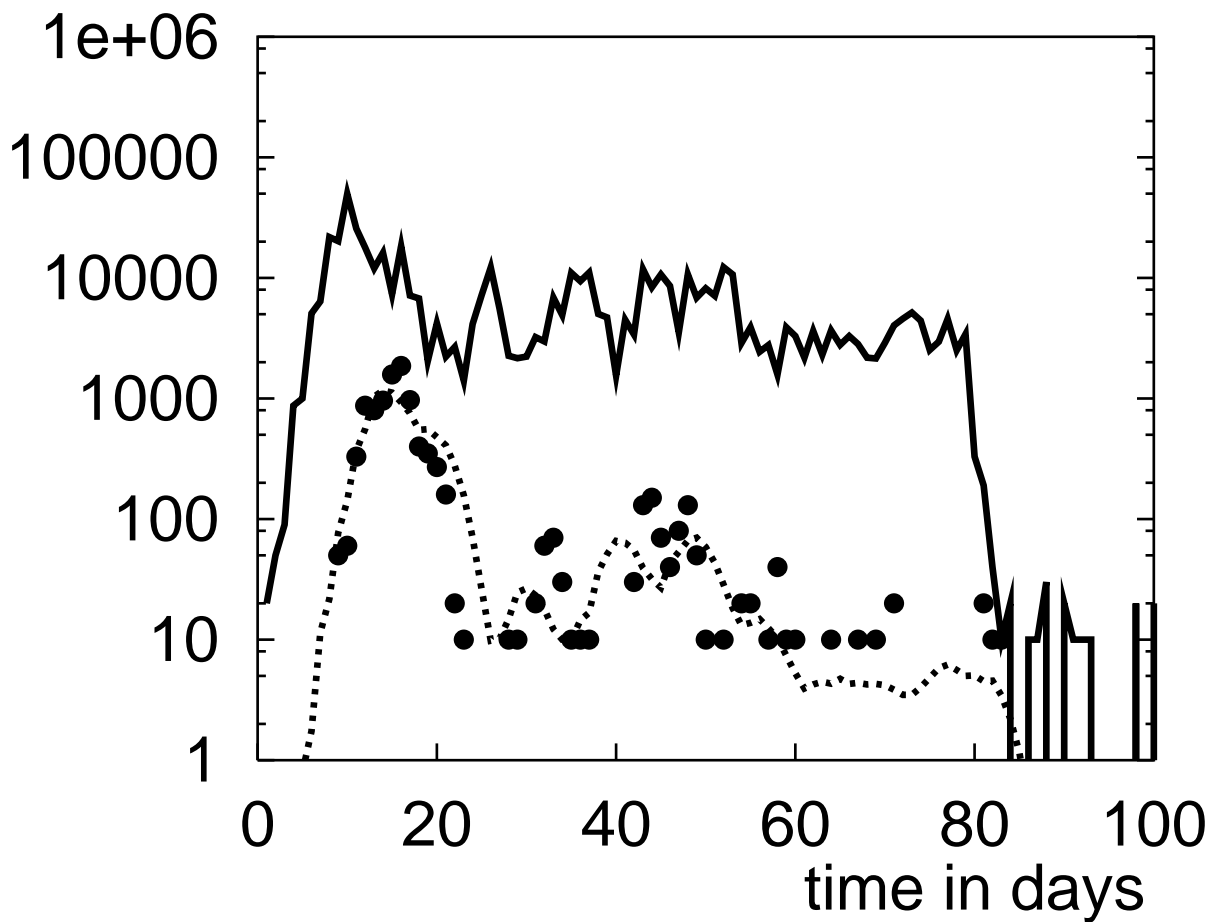
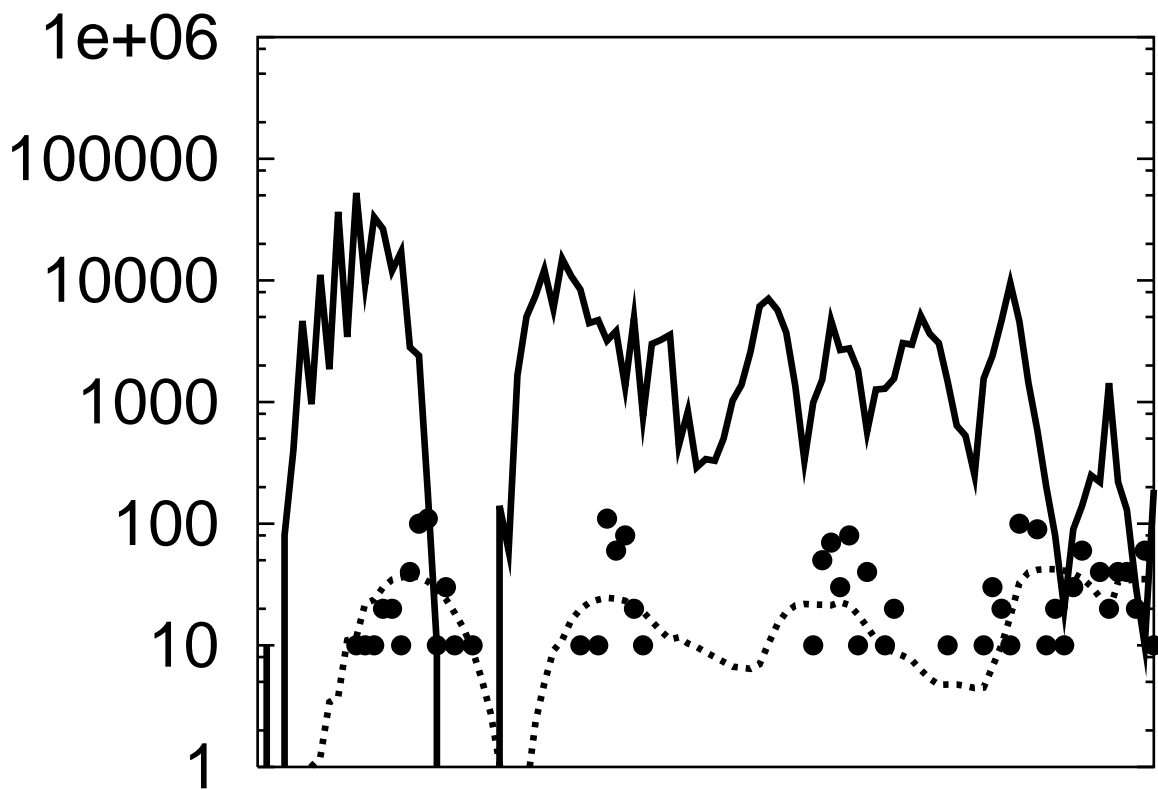
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



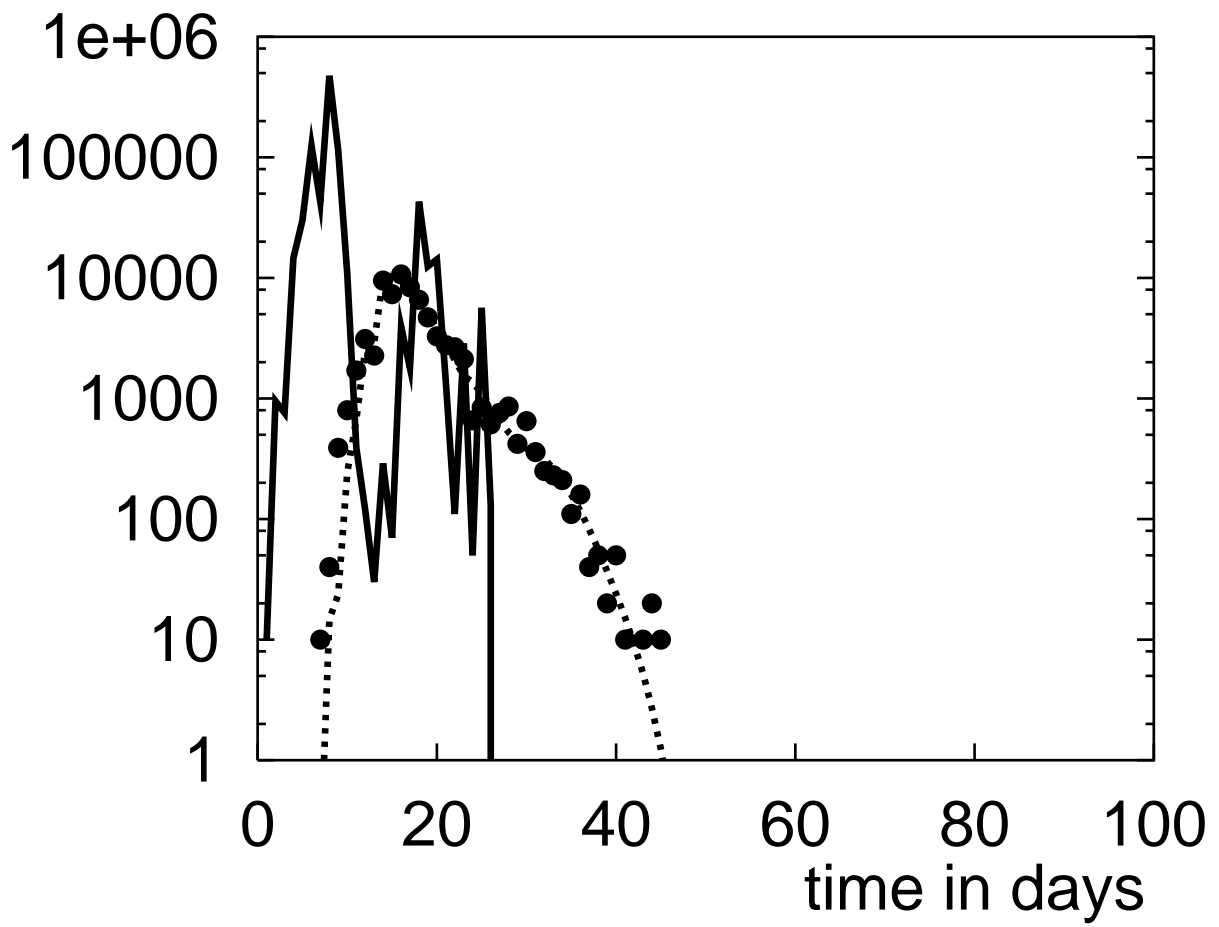
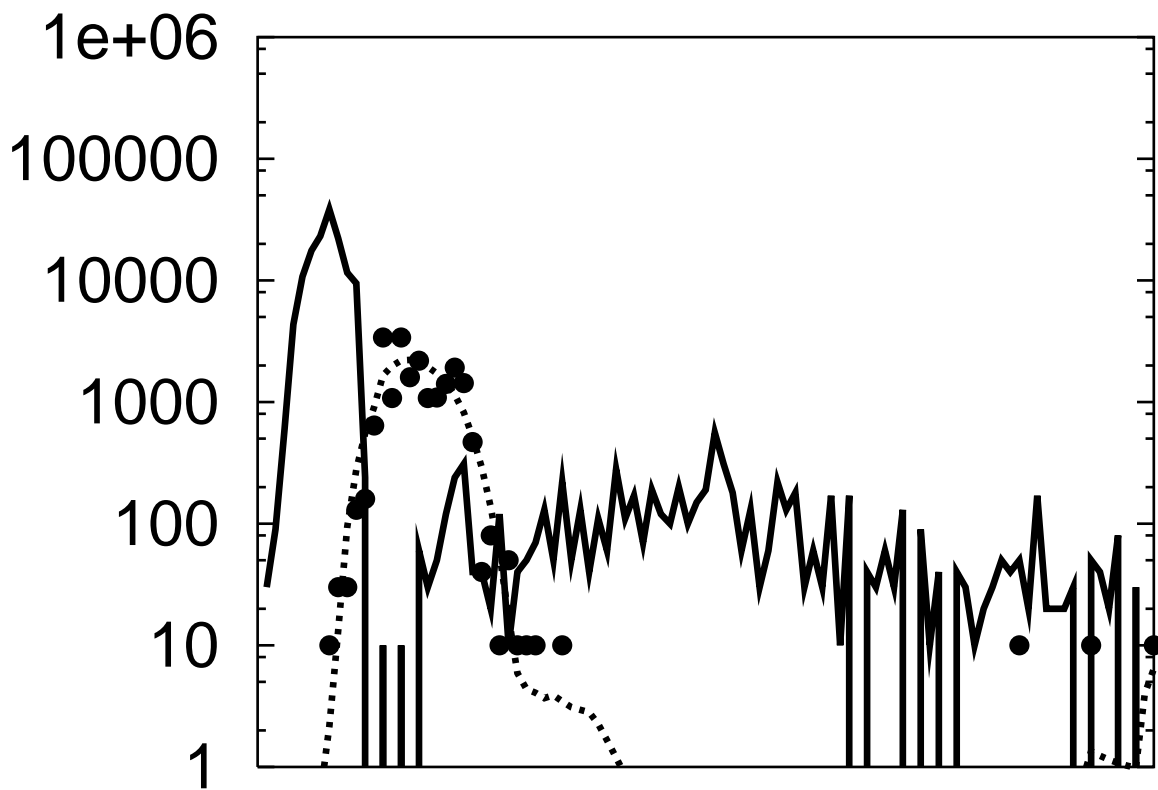
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



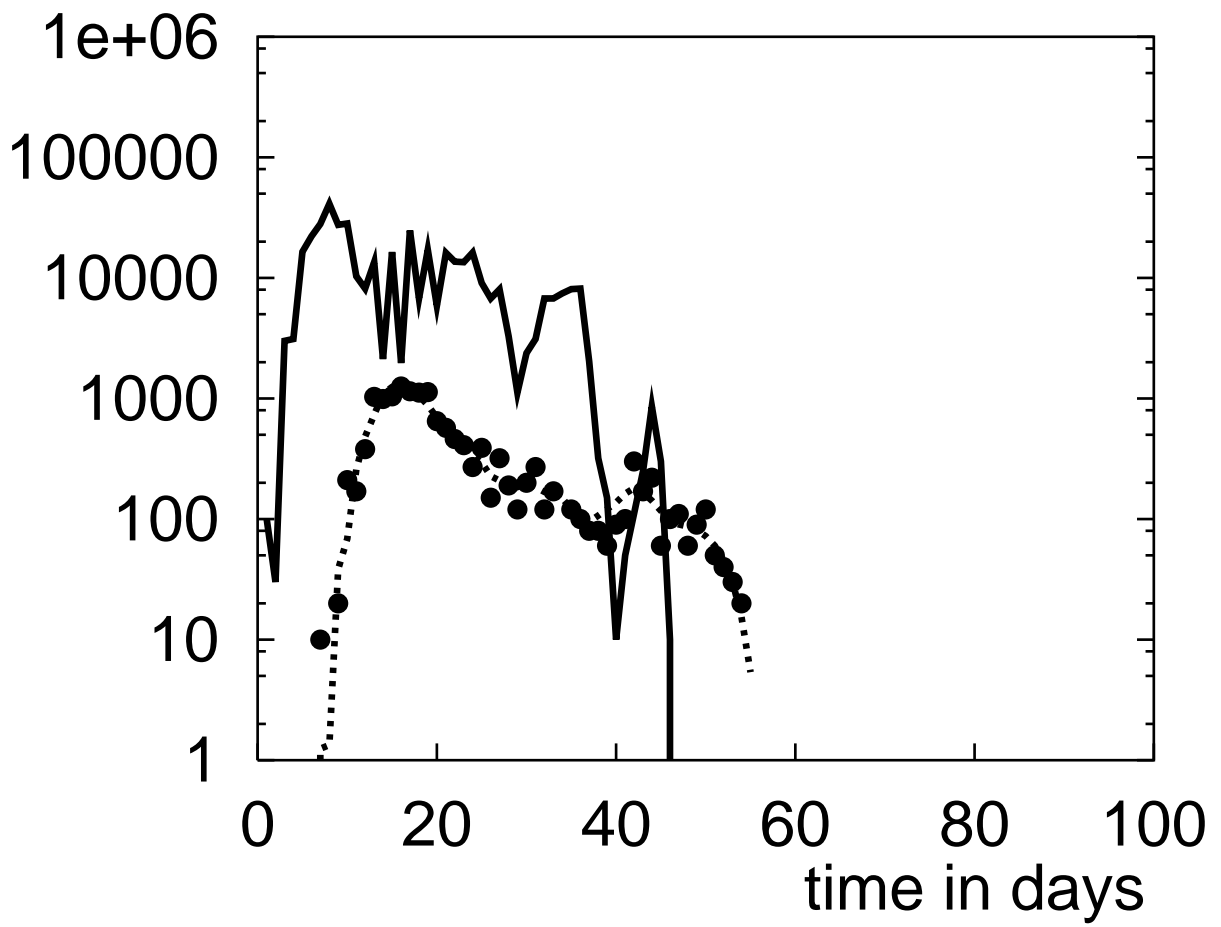
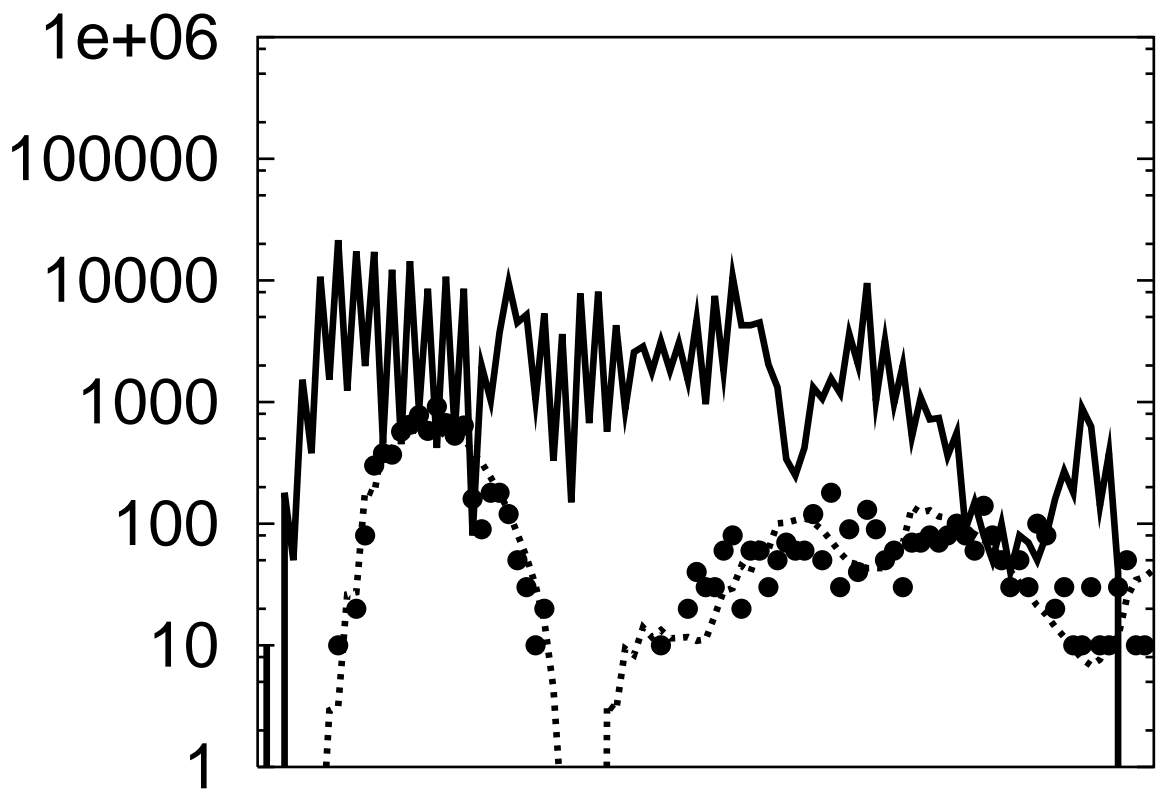
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



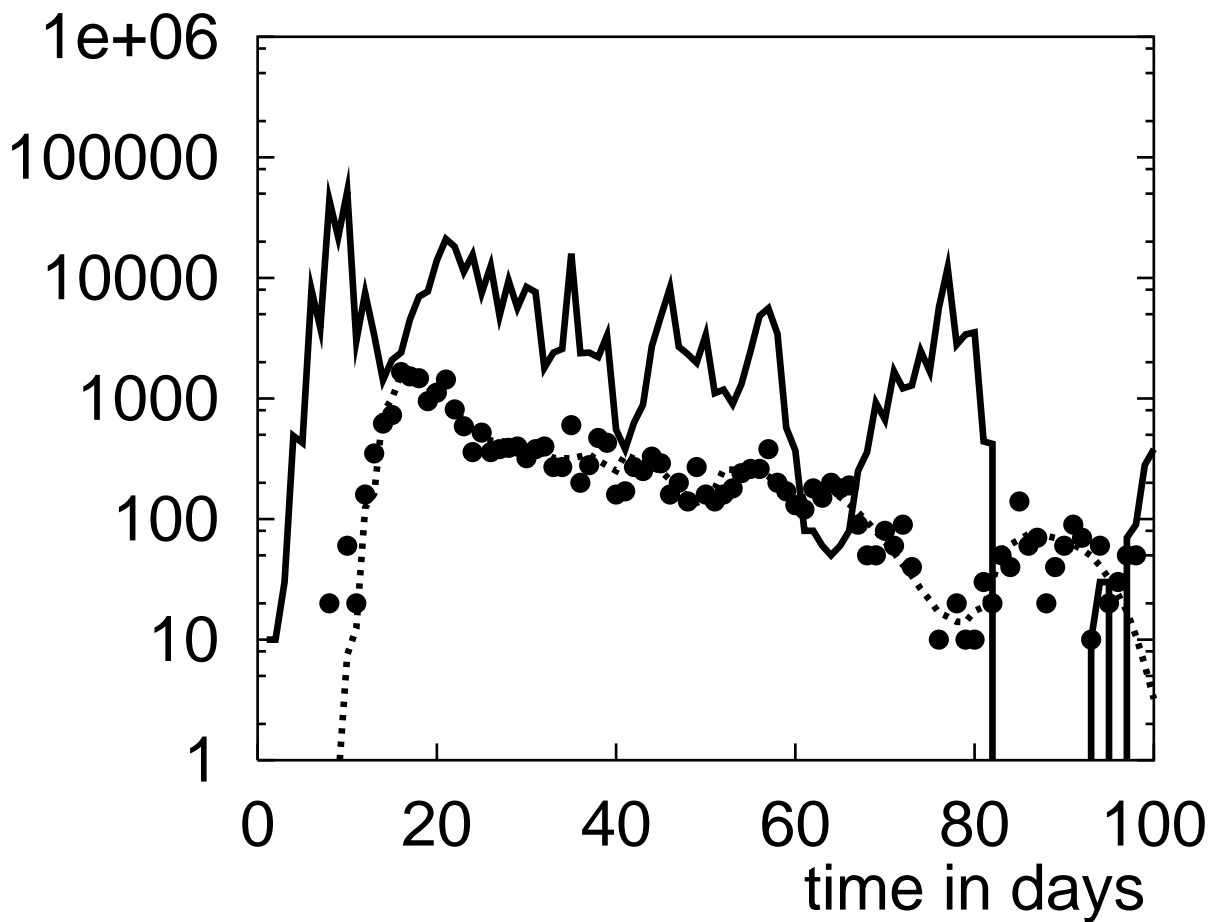
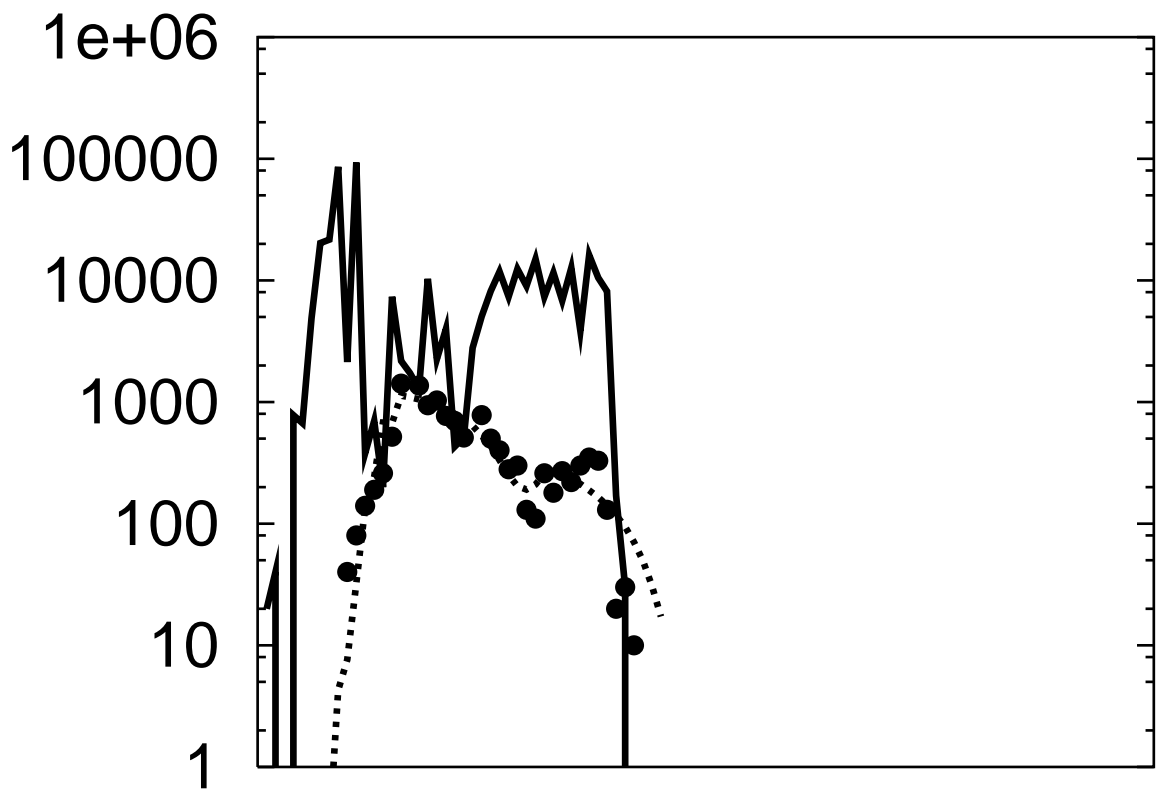
asex. parasites ———
observ. gameto. ●
expect gameto. ·····

parasites per μl blood



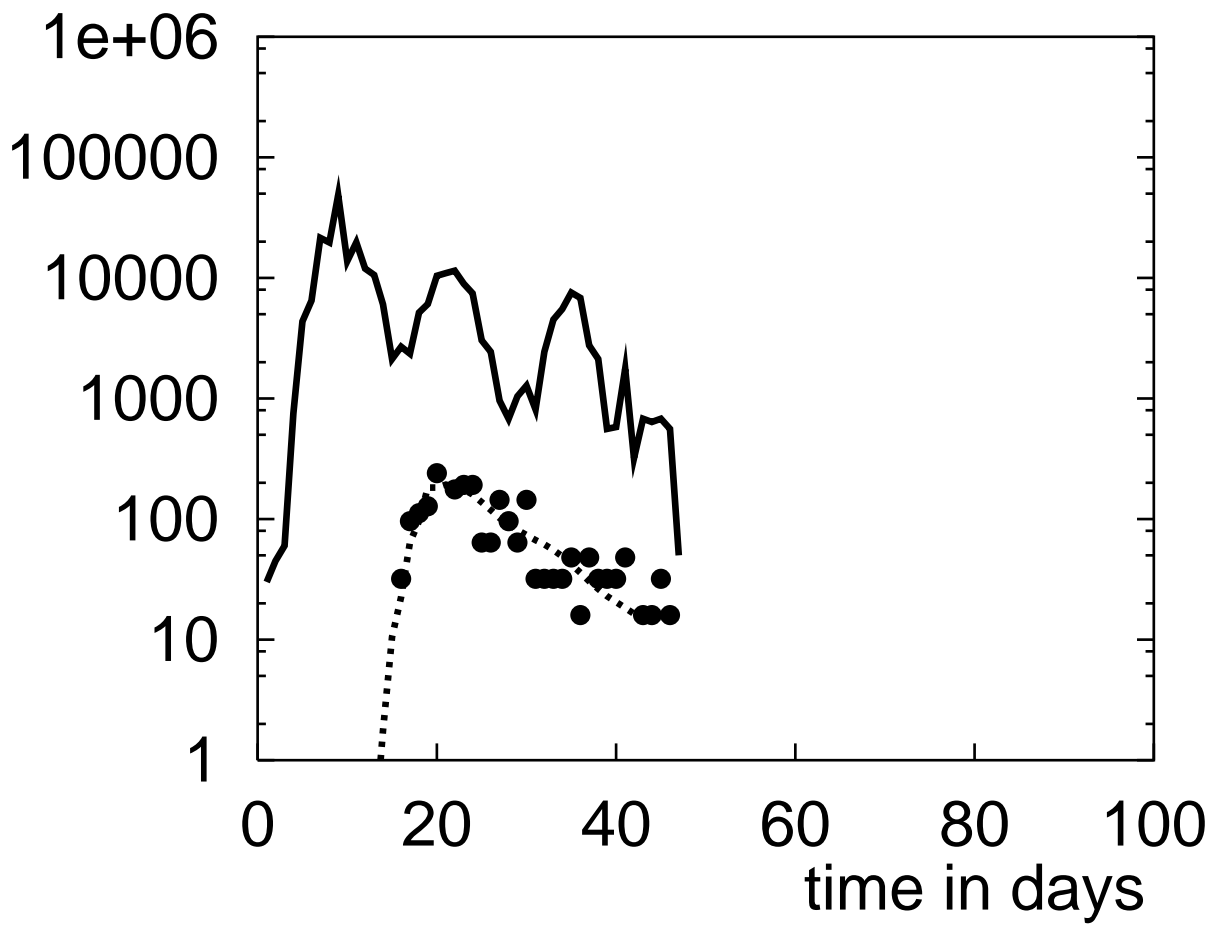
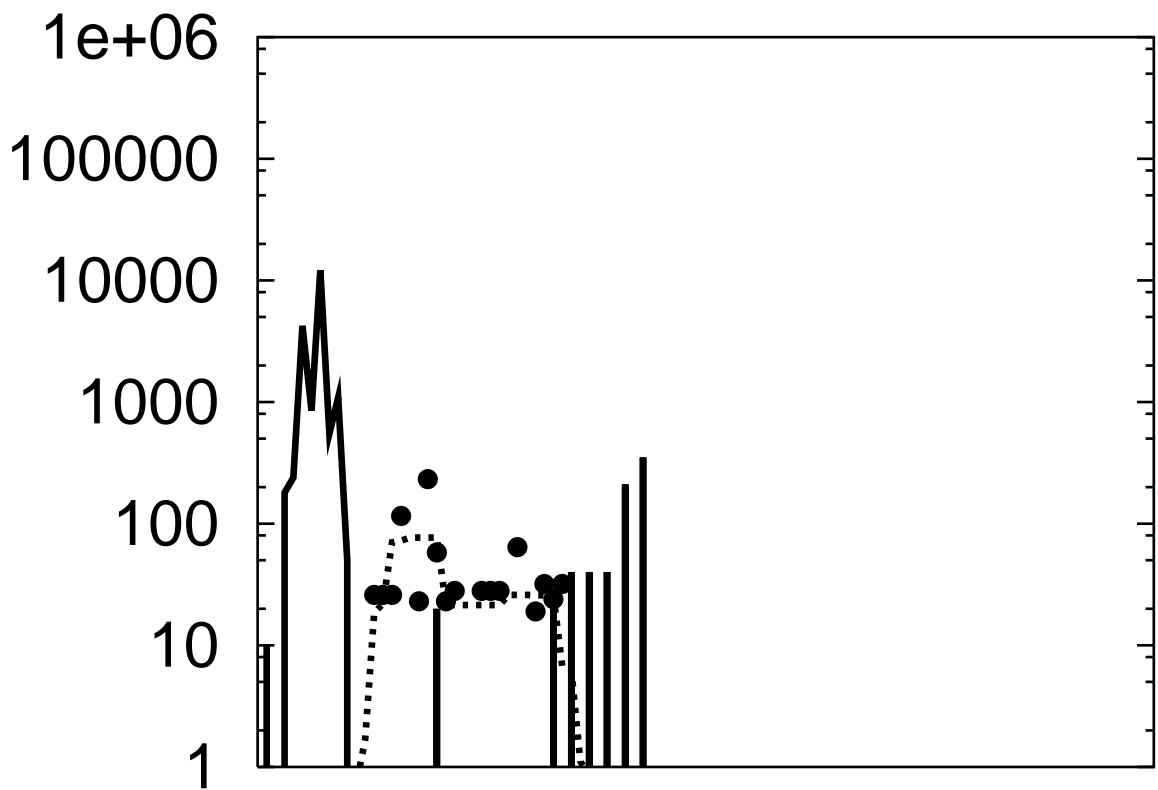
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



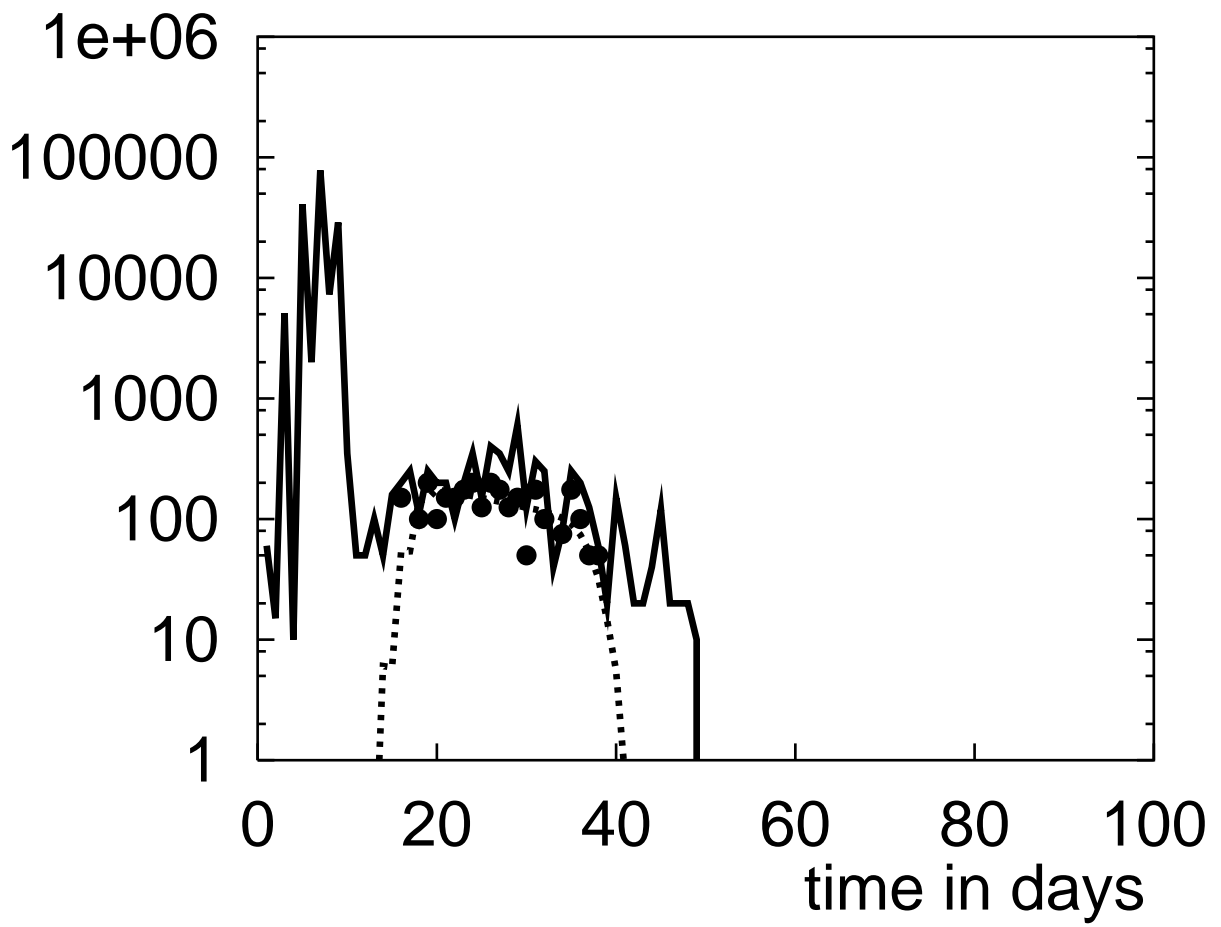
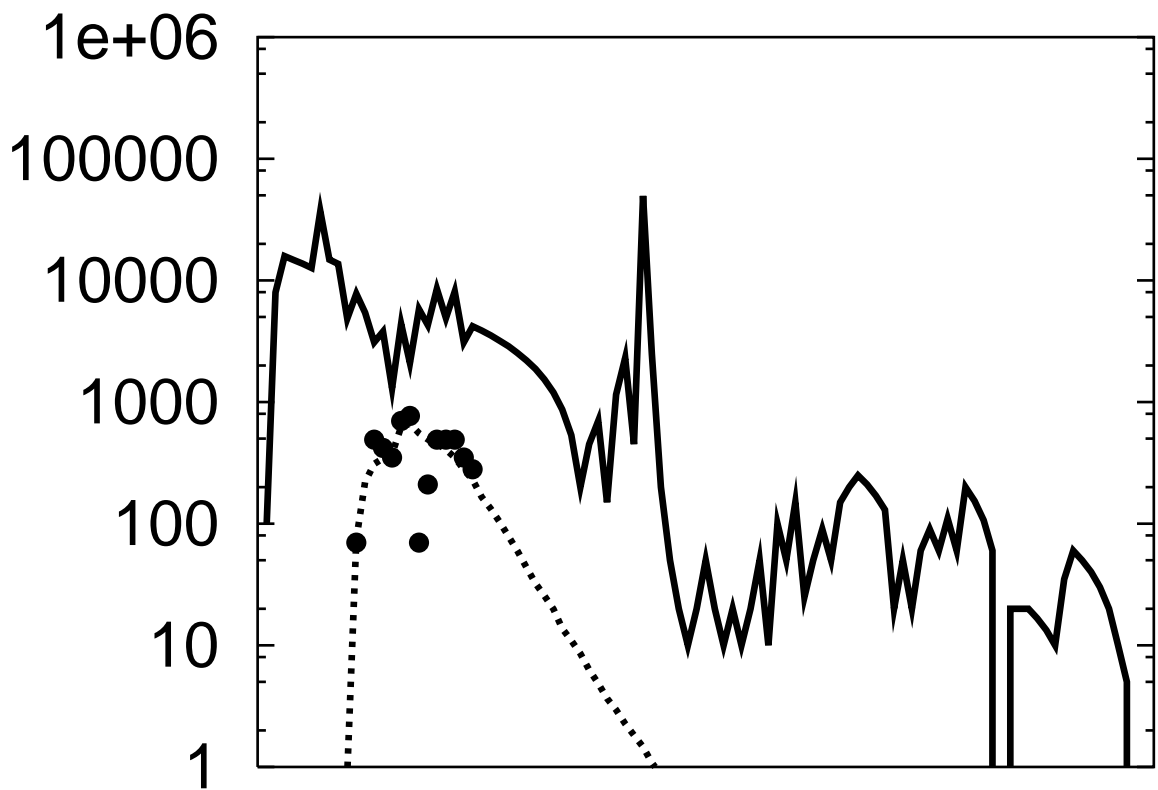
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



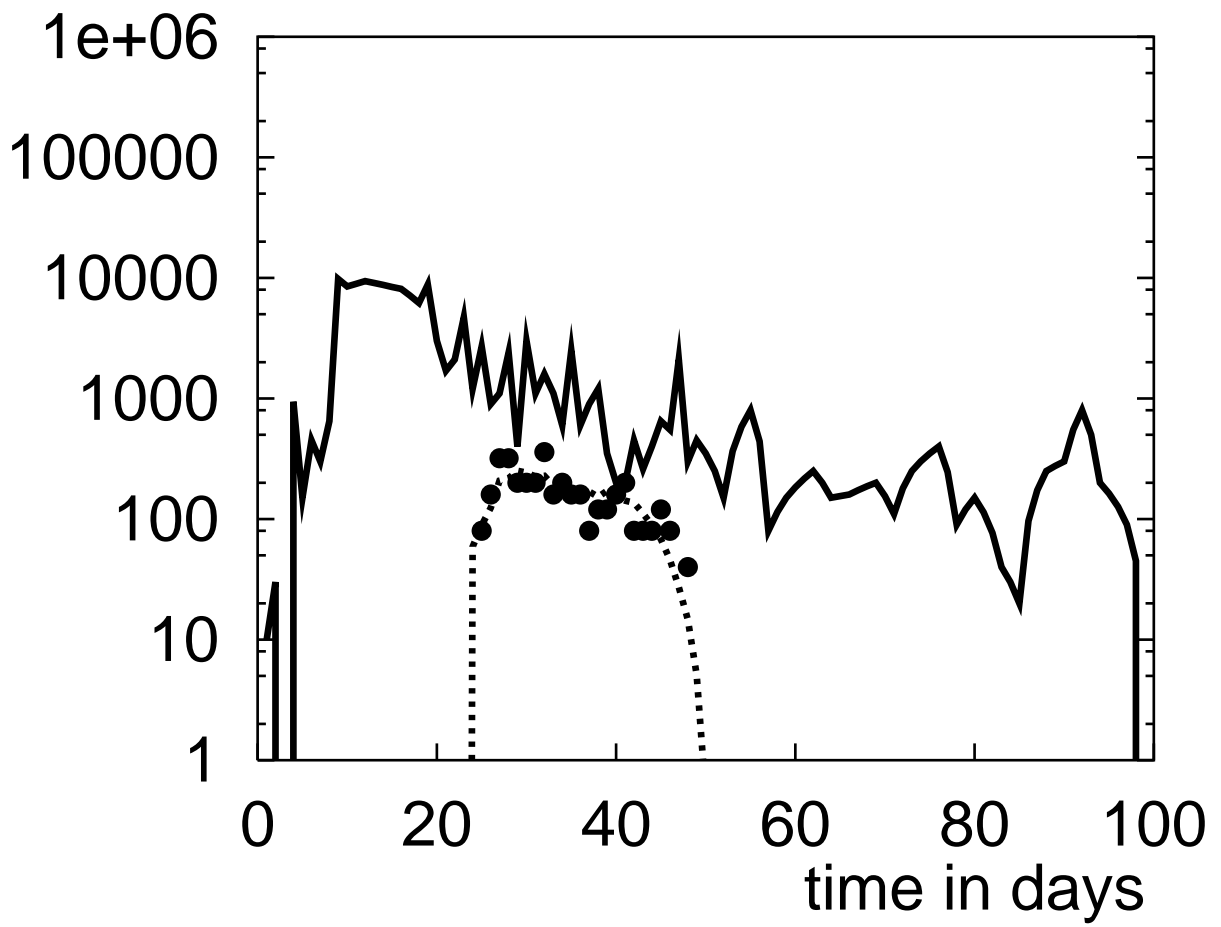
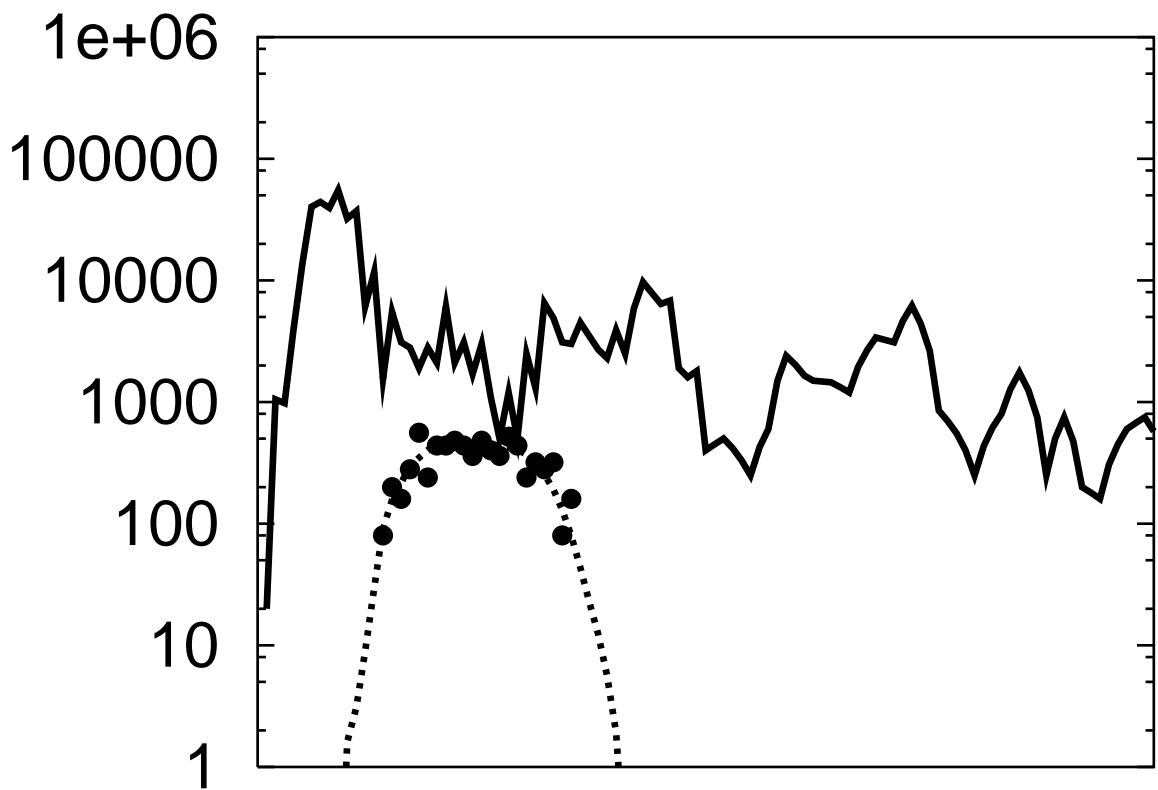
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



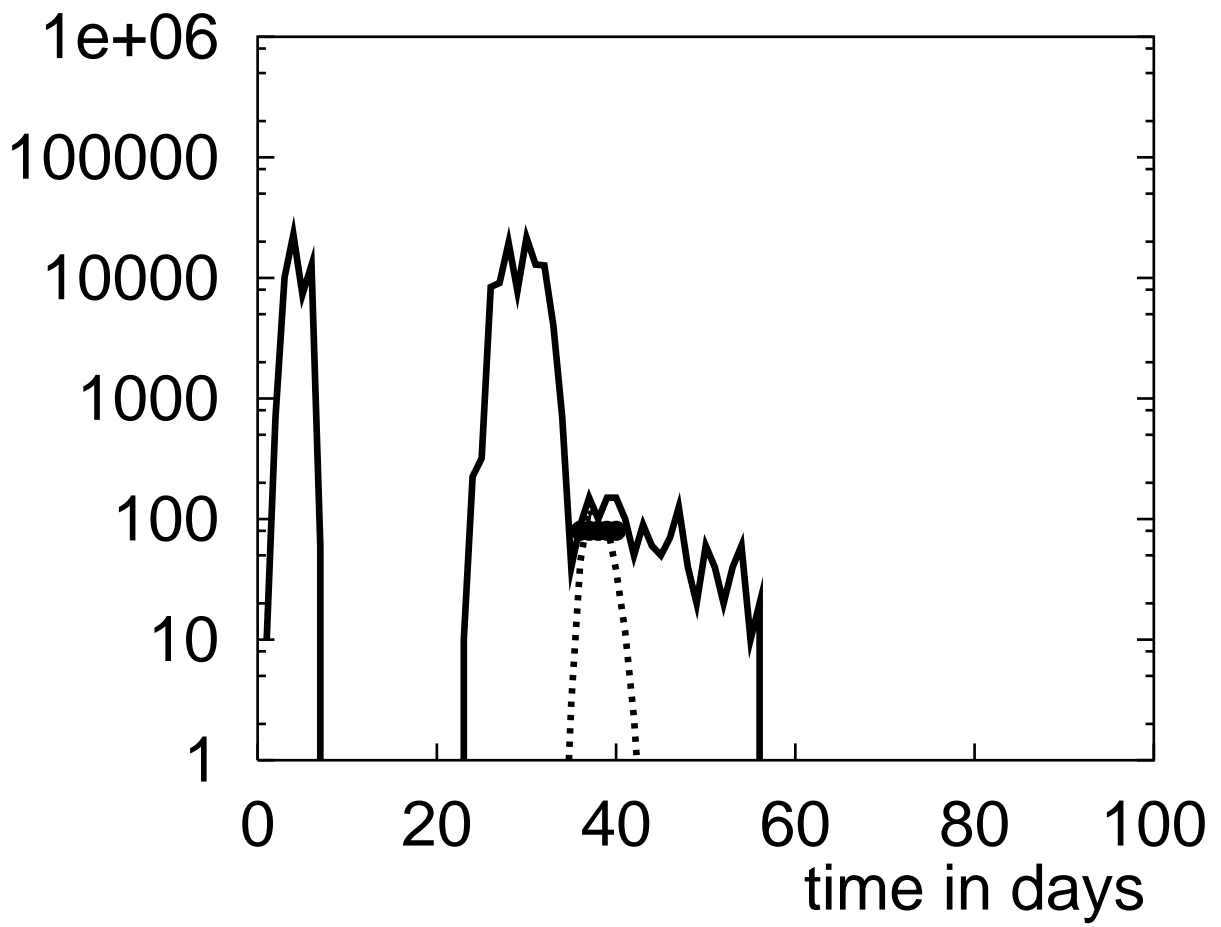
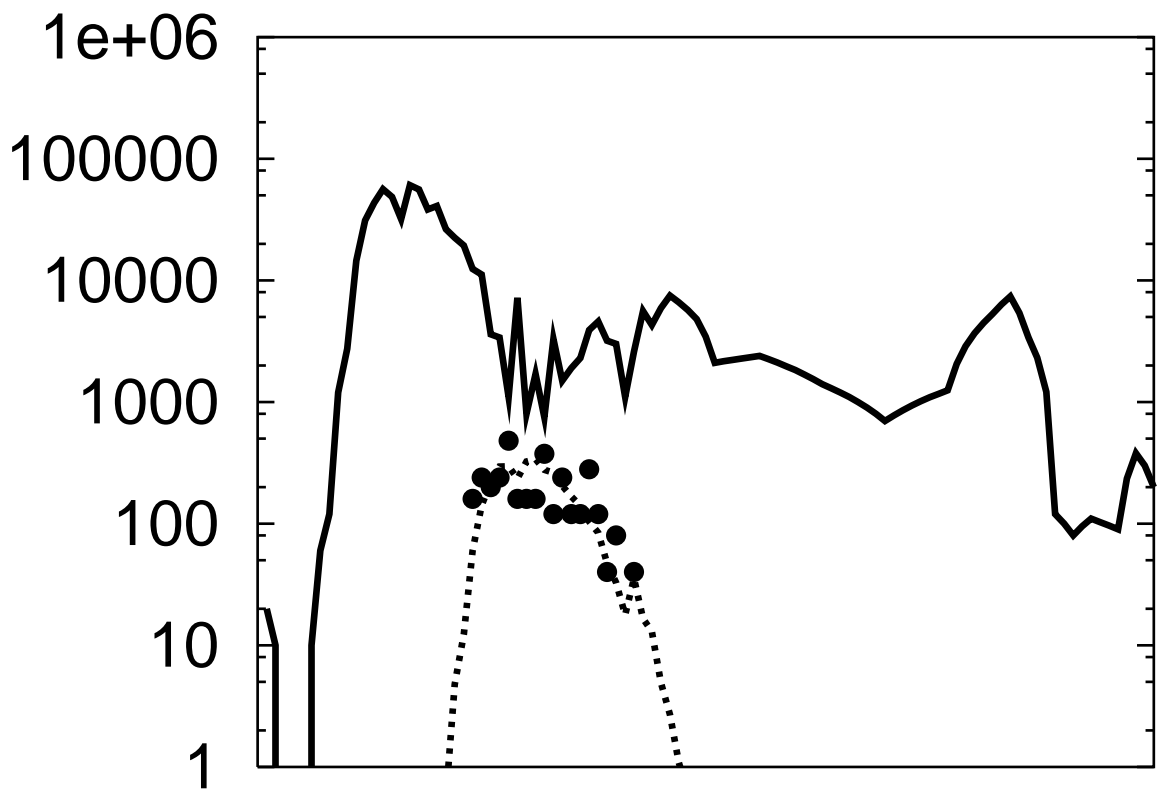
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



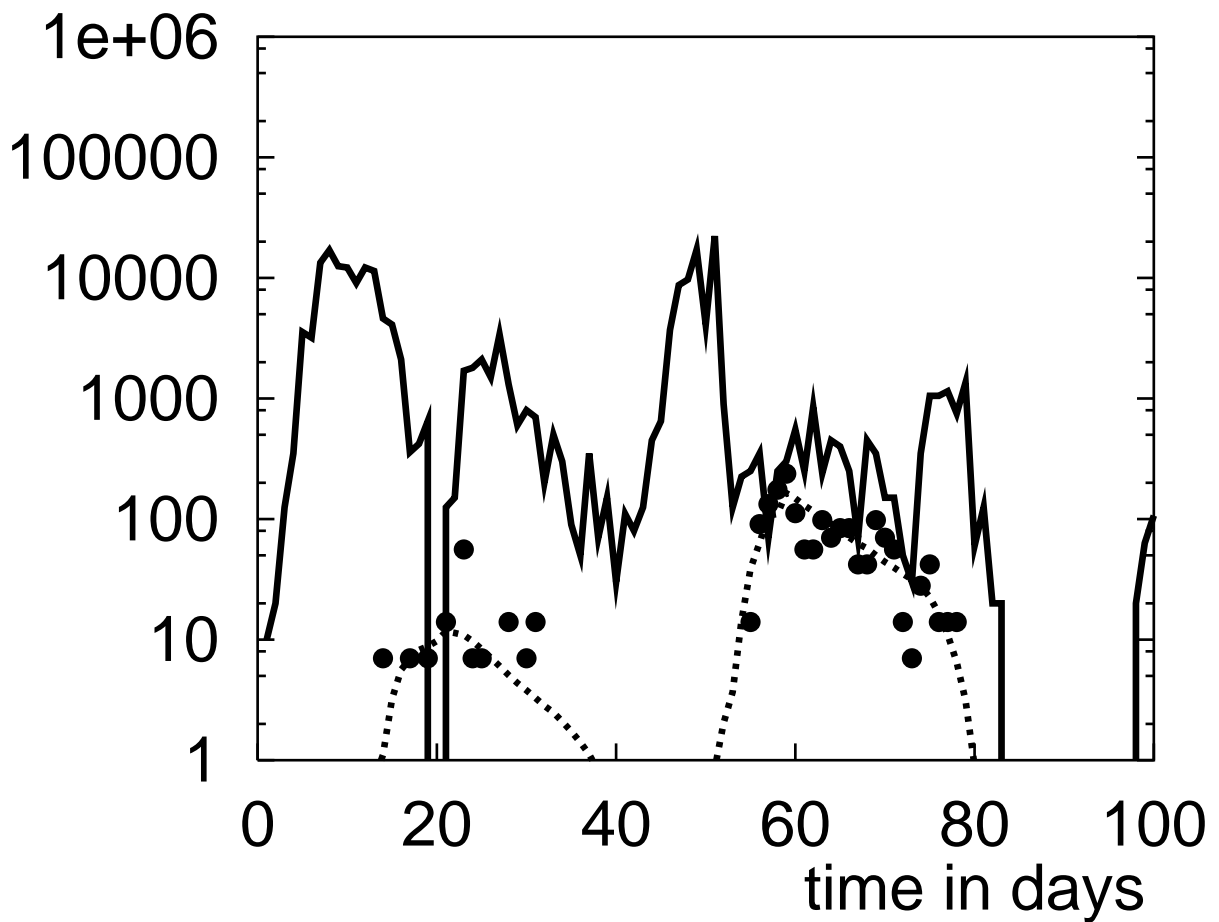
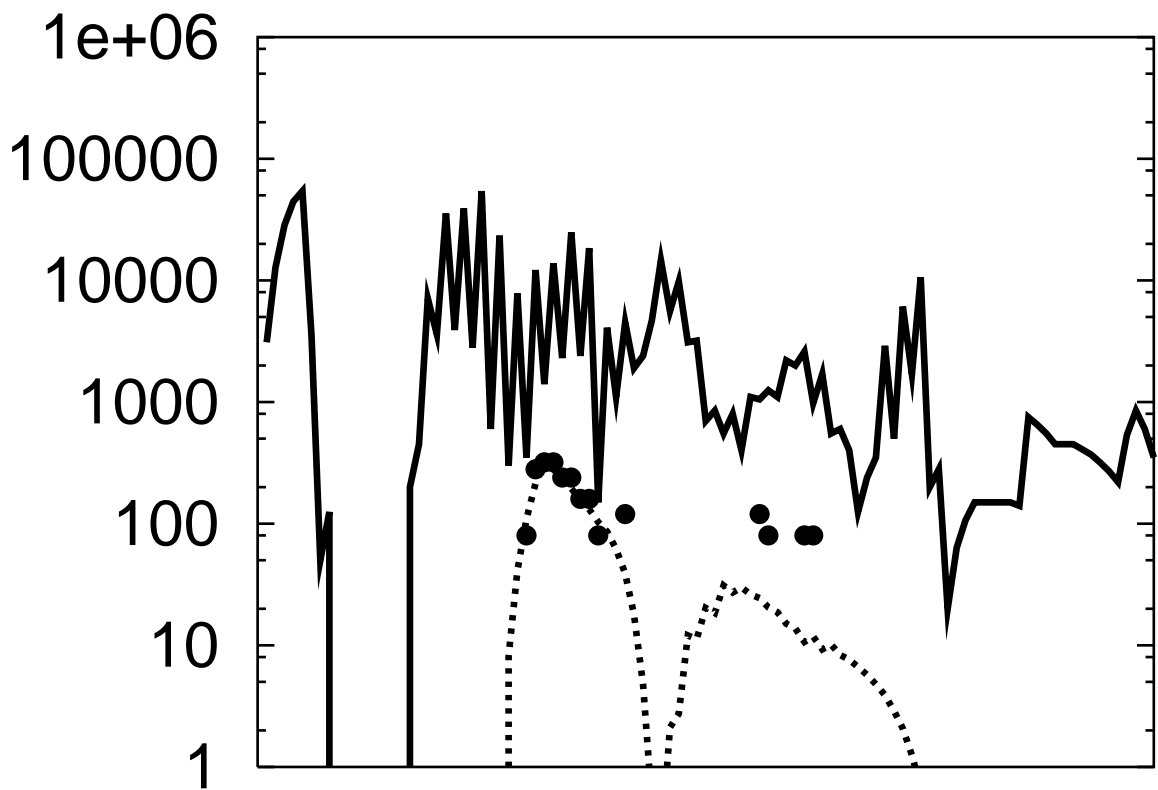
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



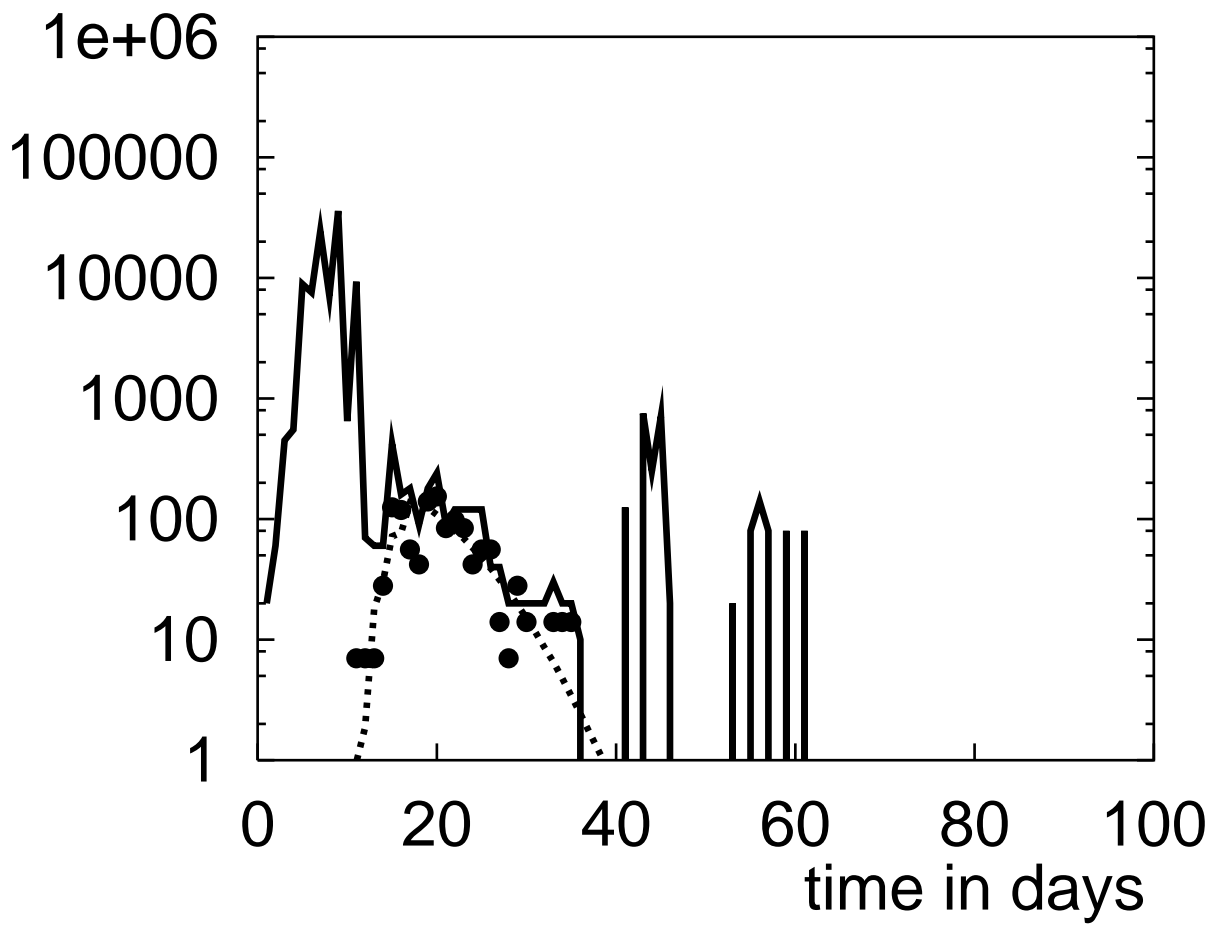
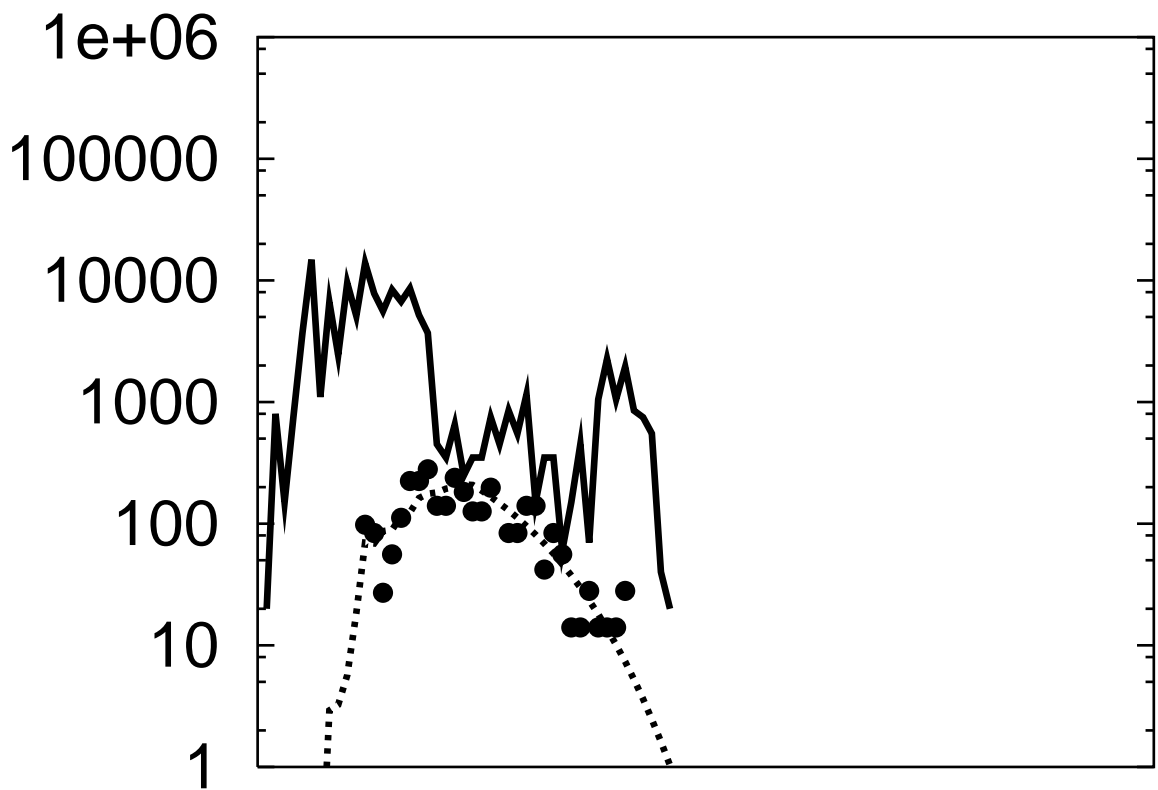
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



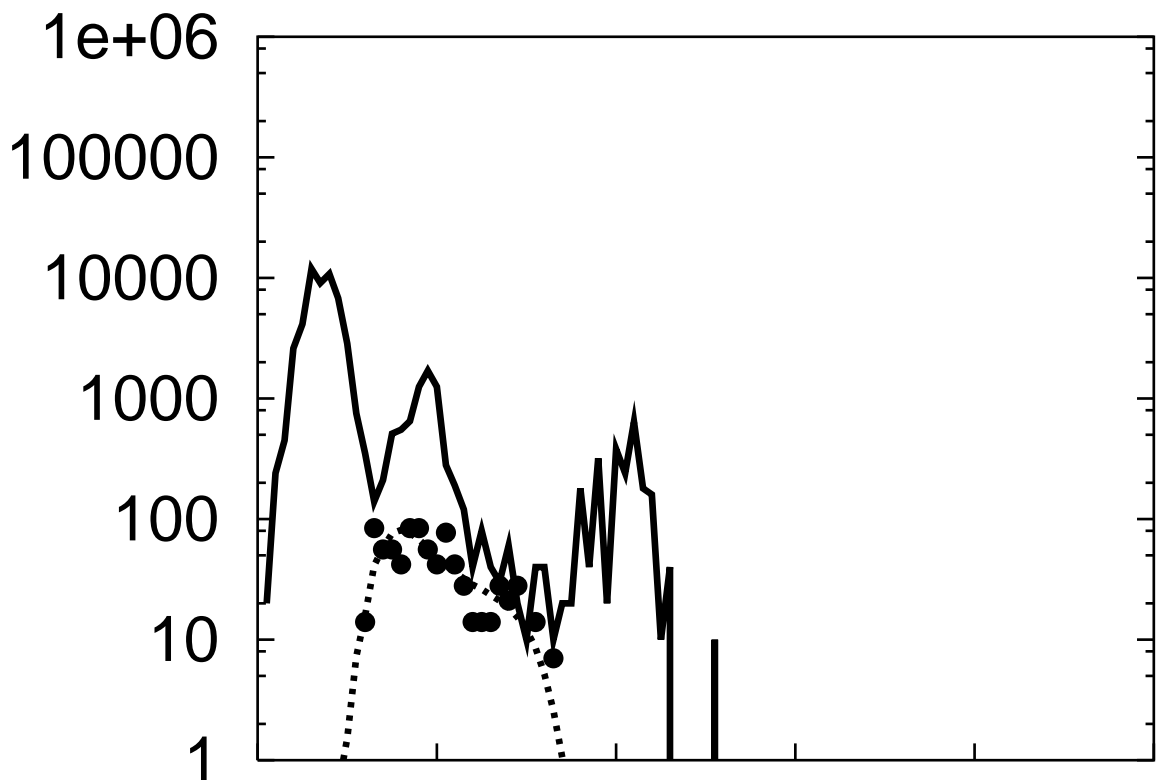
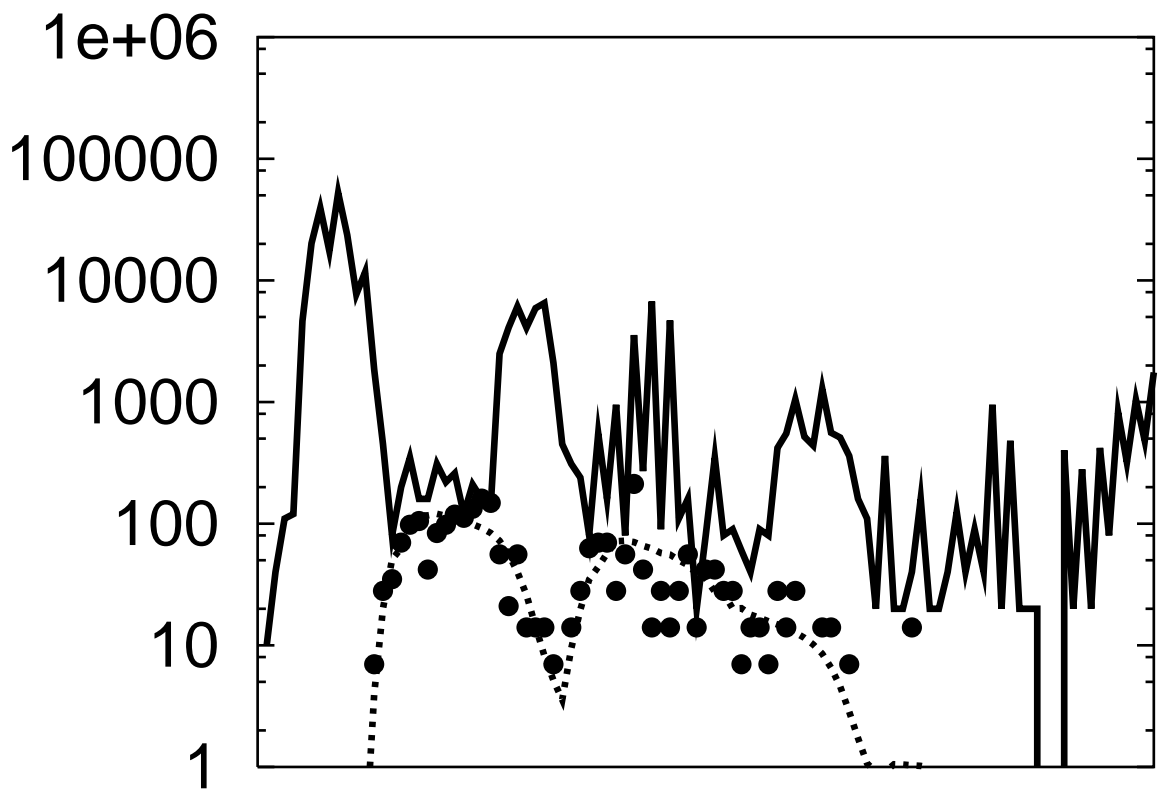
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



asex. parasites ———
observ. gameto. •
expect gameto. ·····

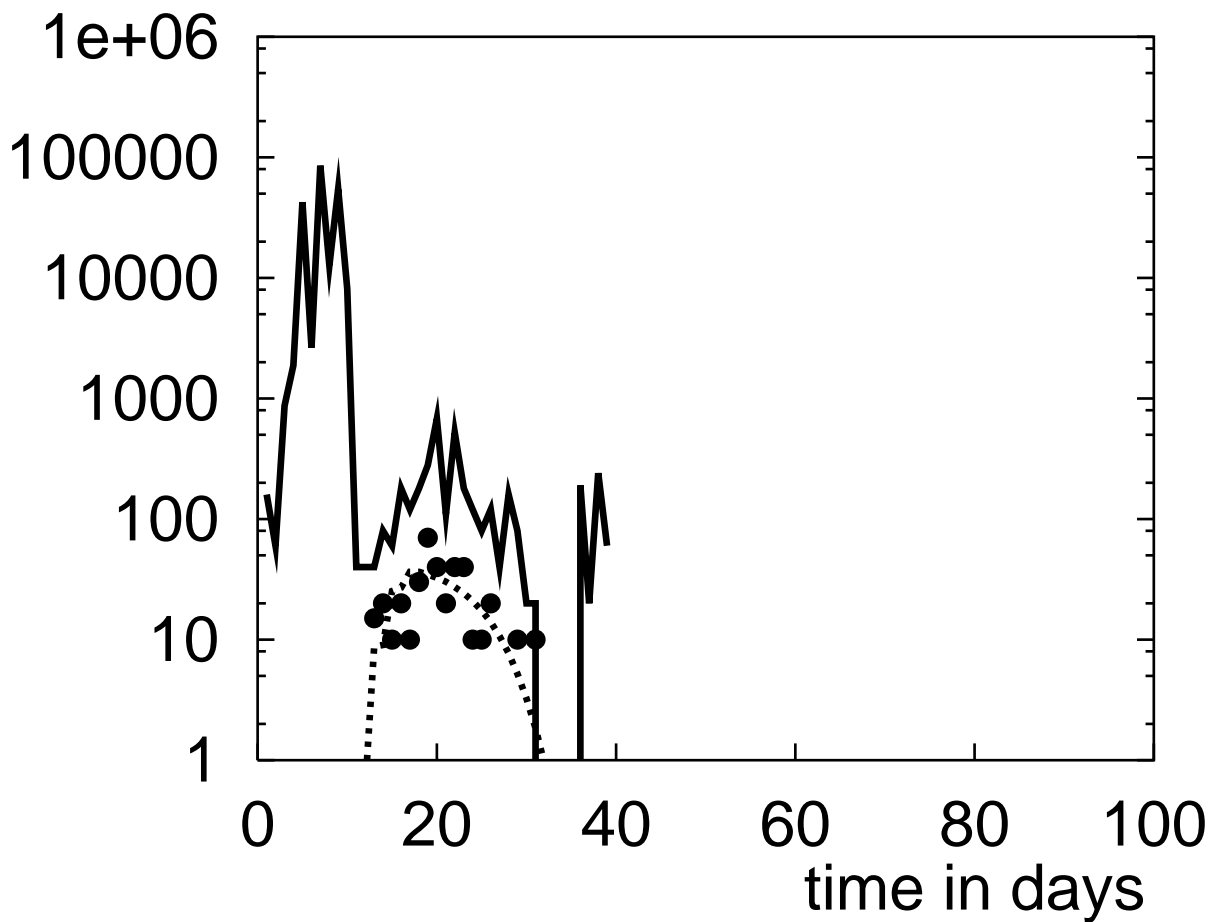
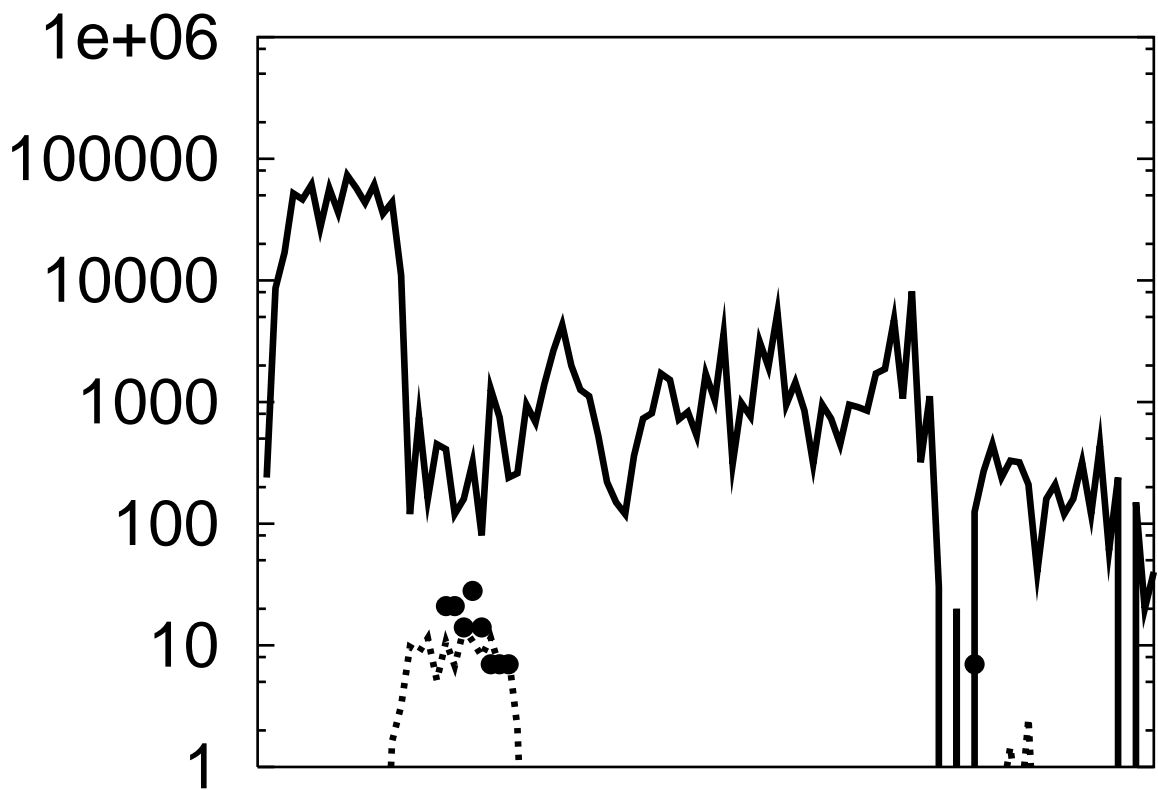
parasites per μl blood



0 20 40 60 80 100
time in days

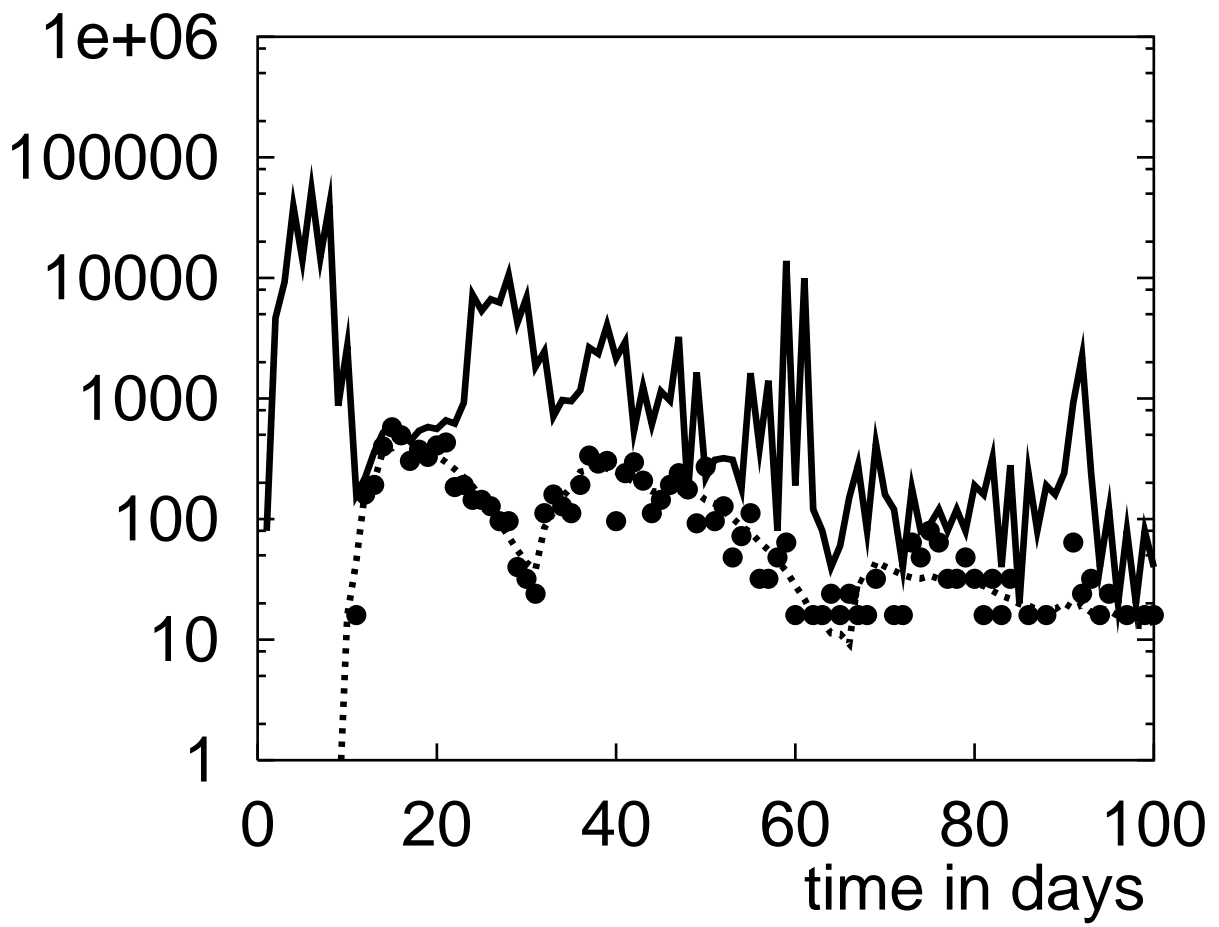
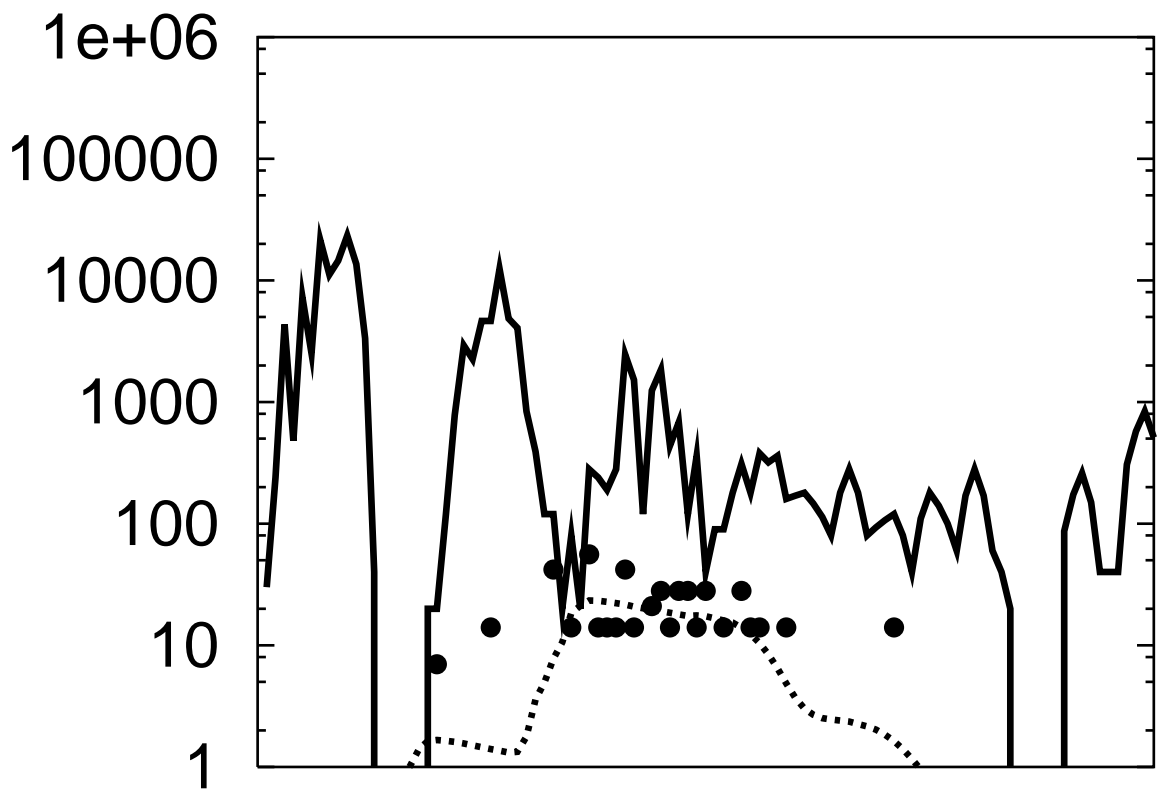
asex. parasites —
observ. gameto. •
expect gameto. ···

parasites per μl blood



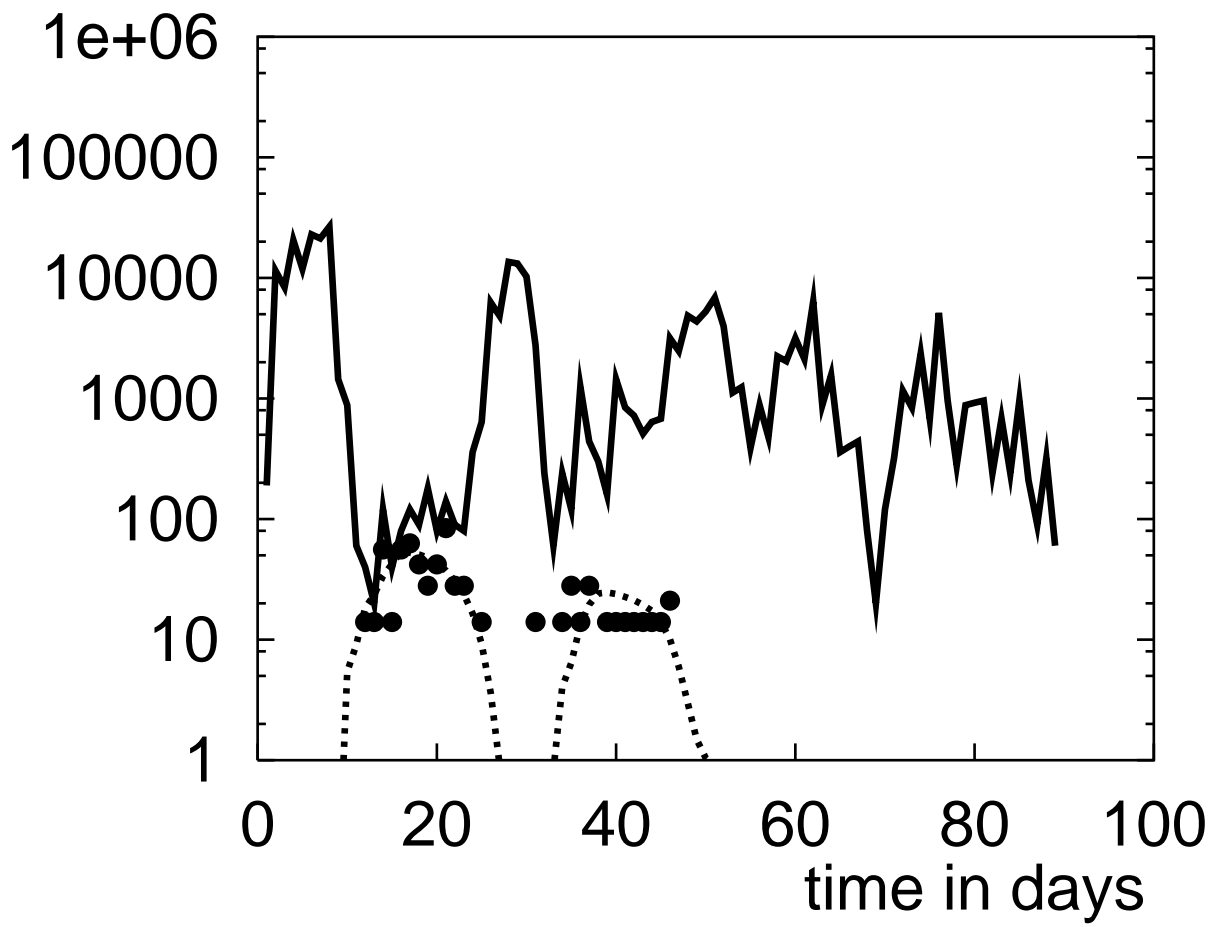
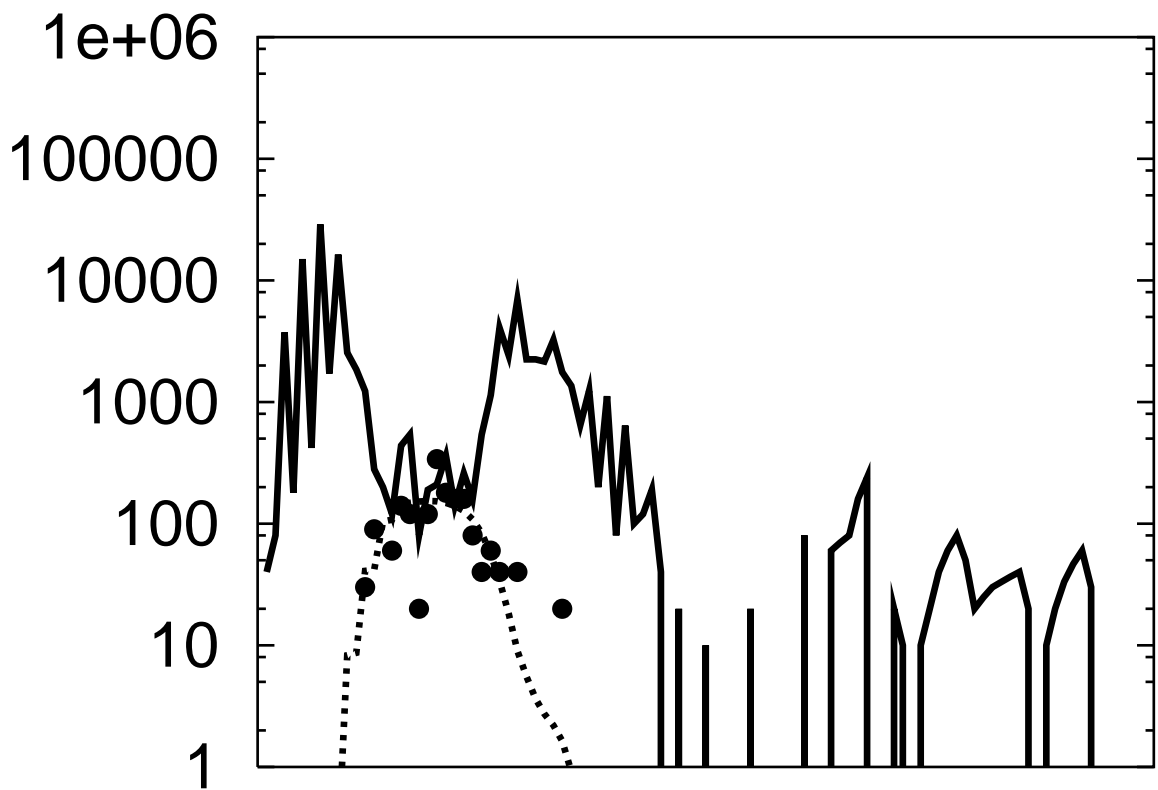
asex. parasites —————
observ. gameto. •
expect gameto. ······

parasites per μl blood



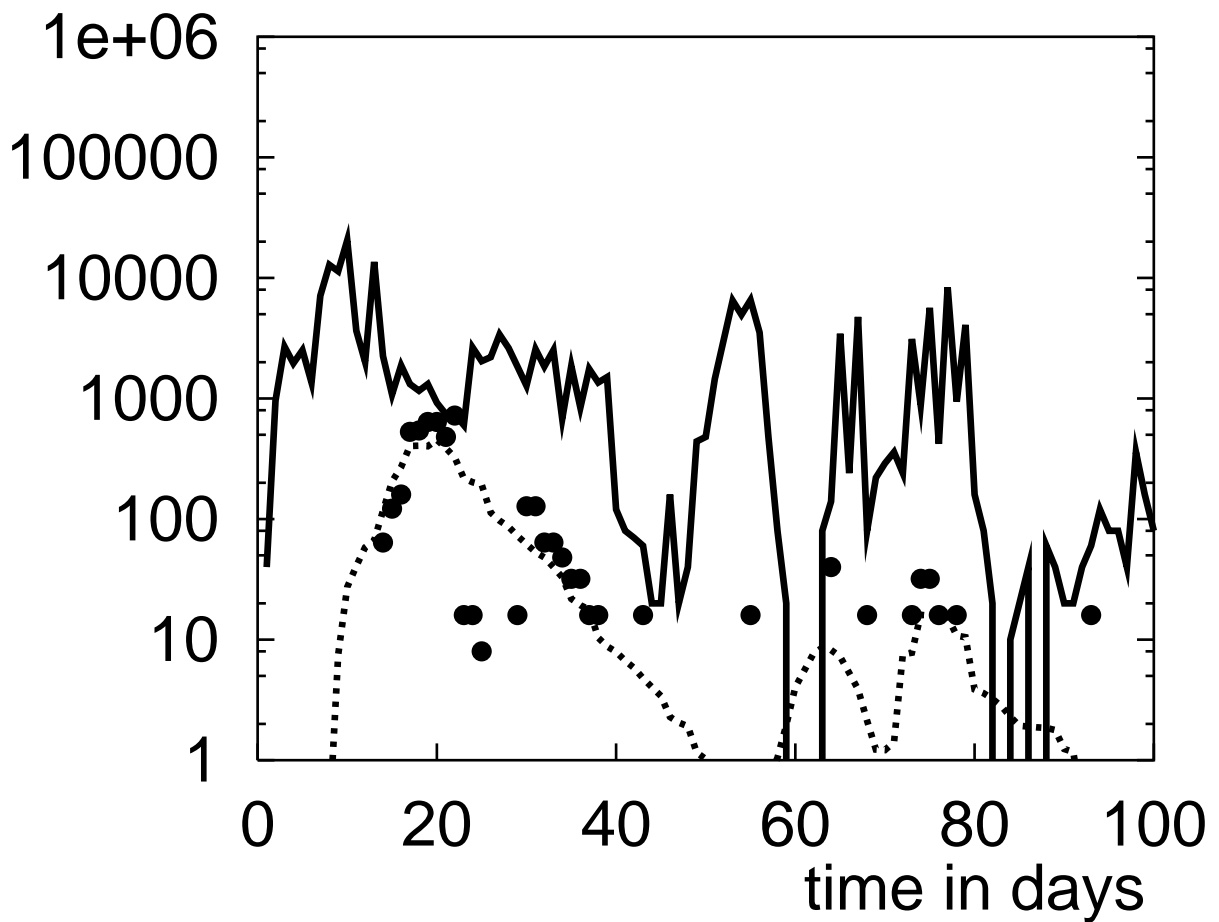
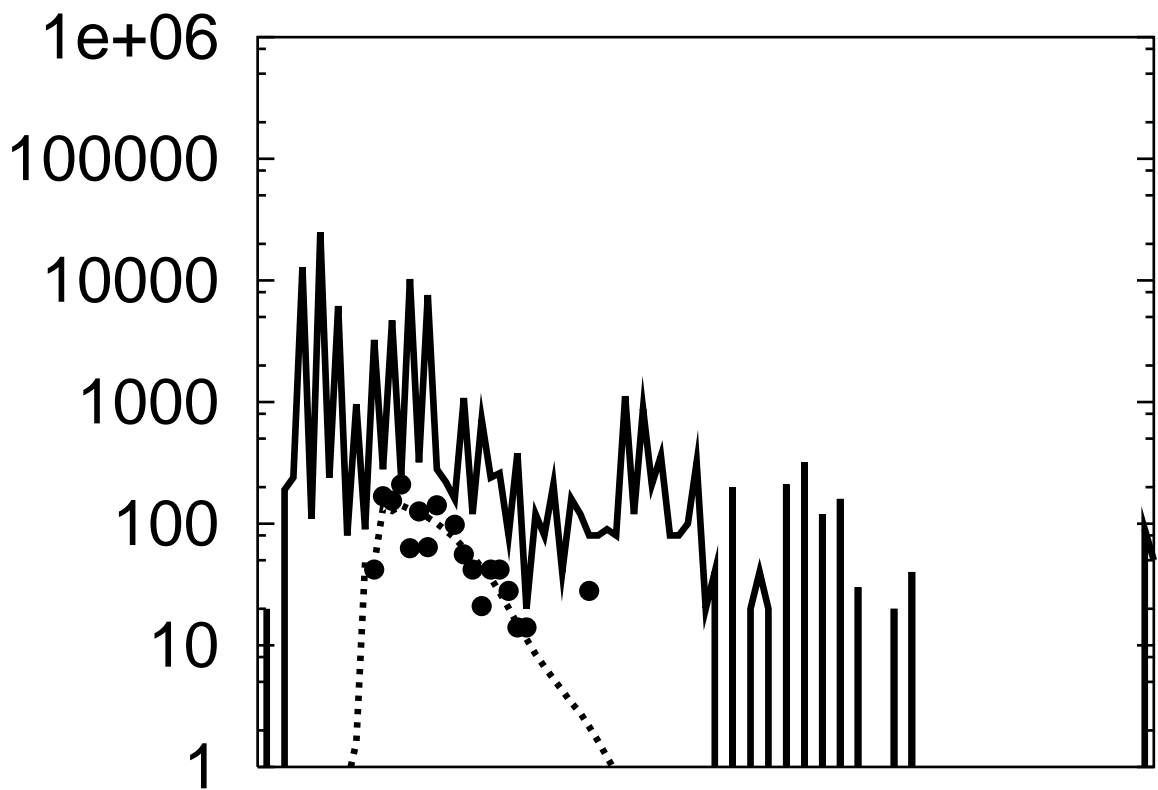
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



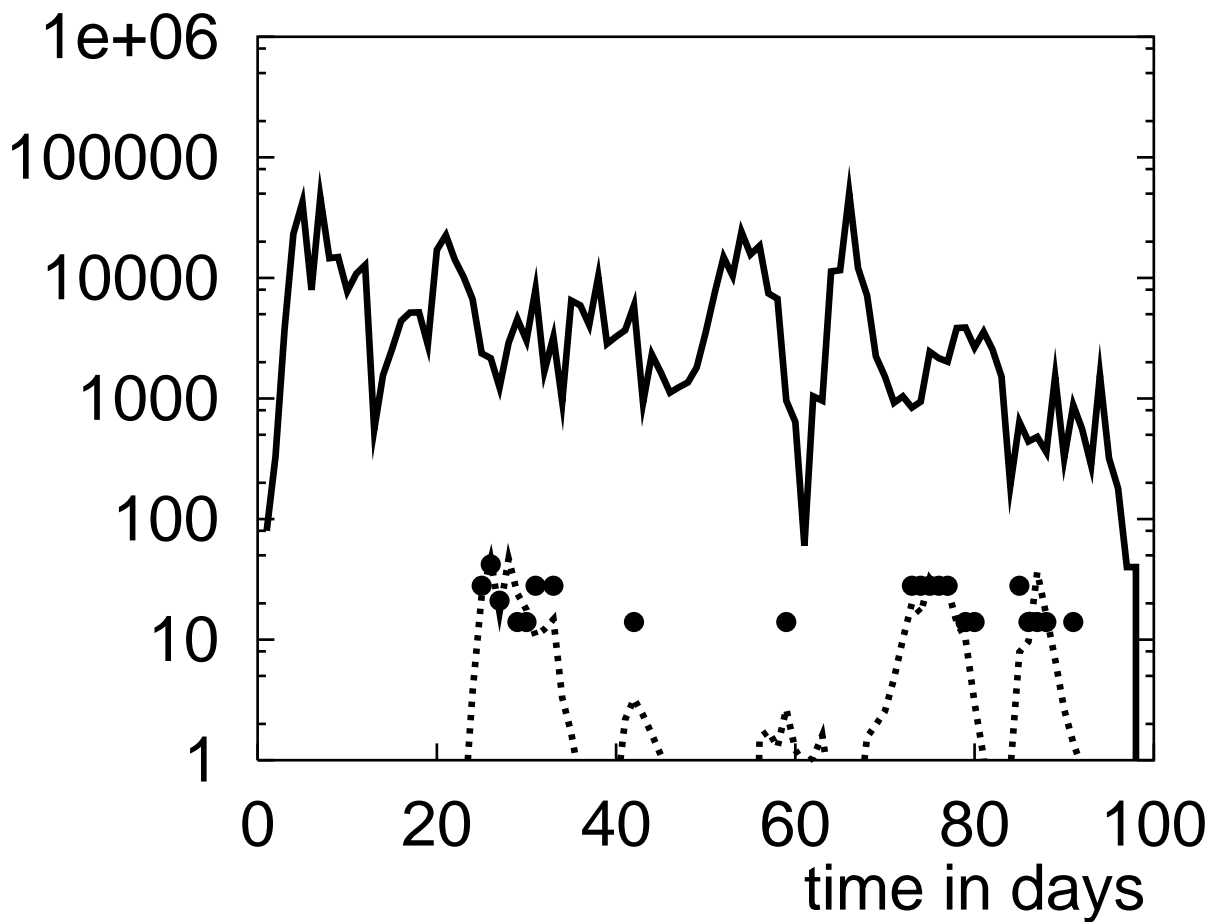
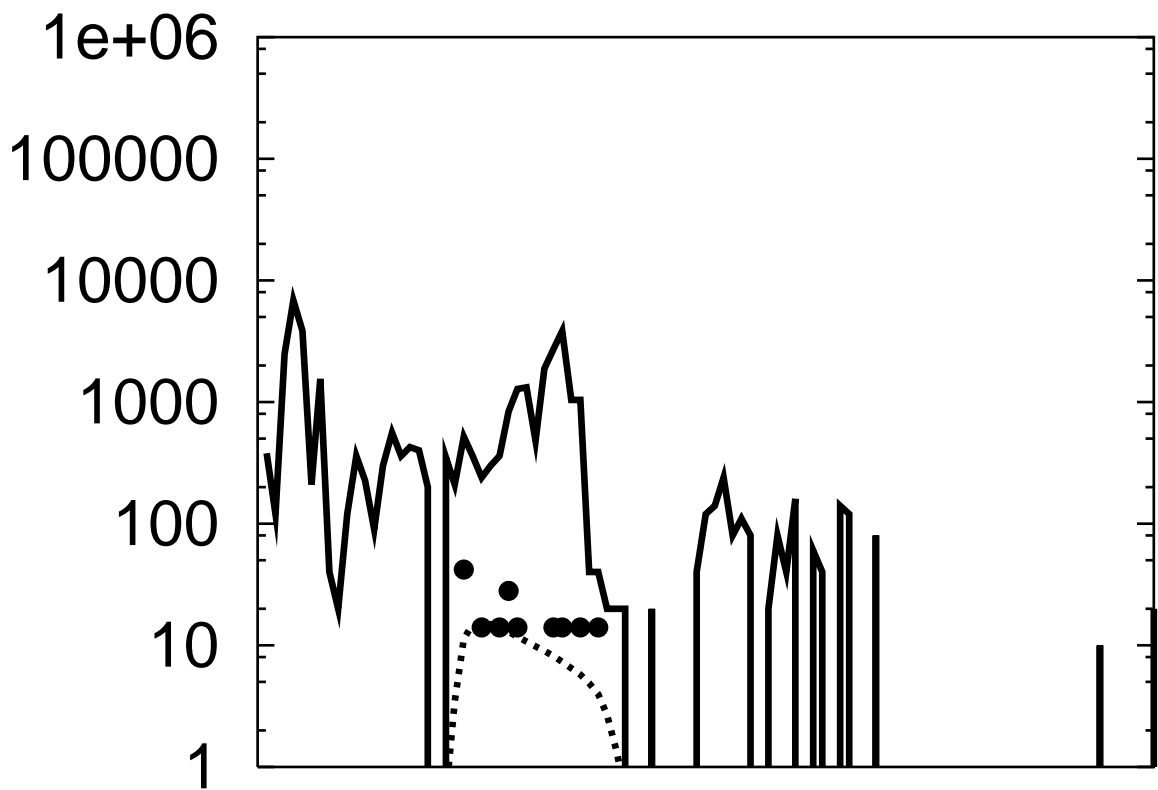
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



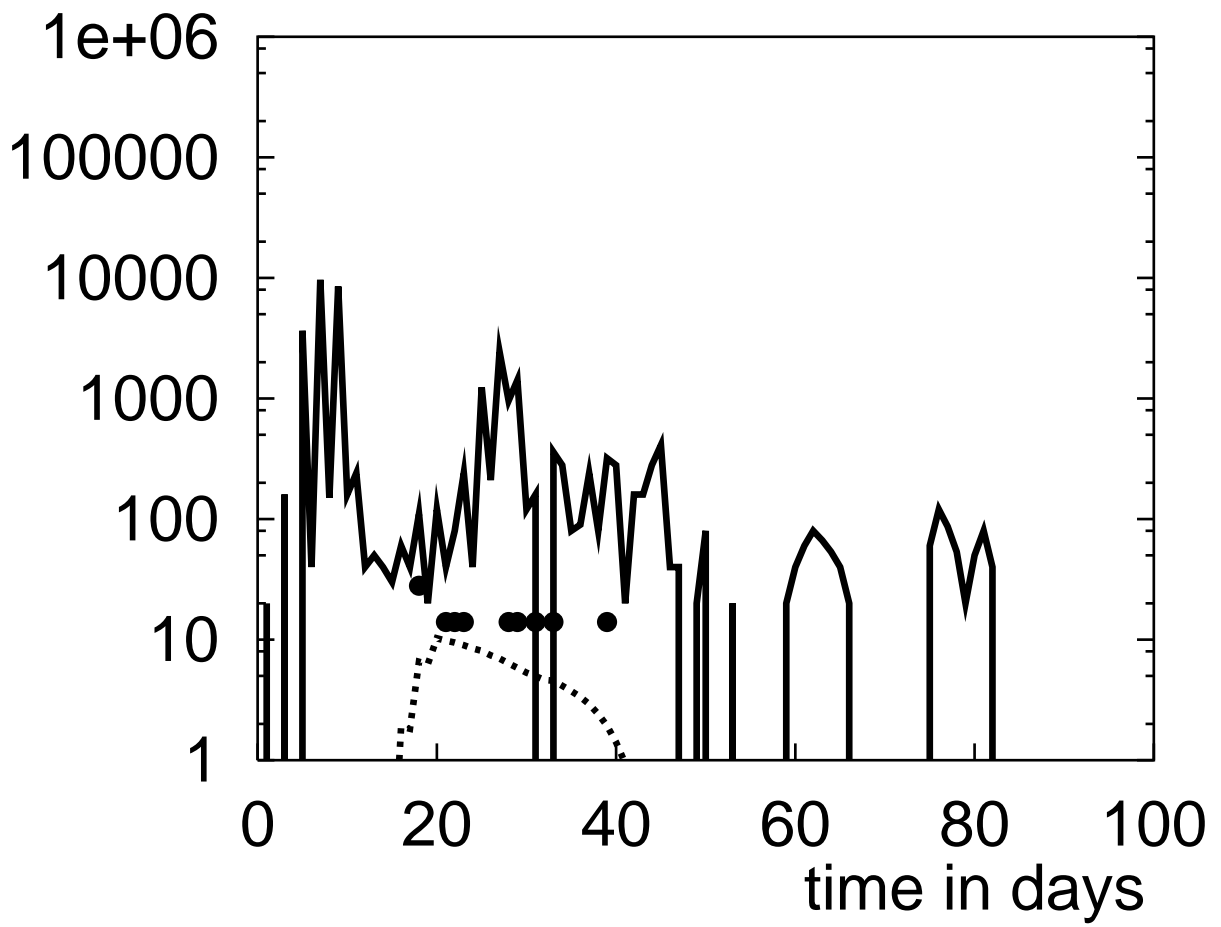
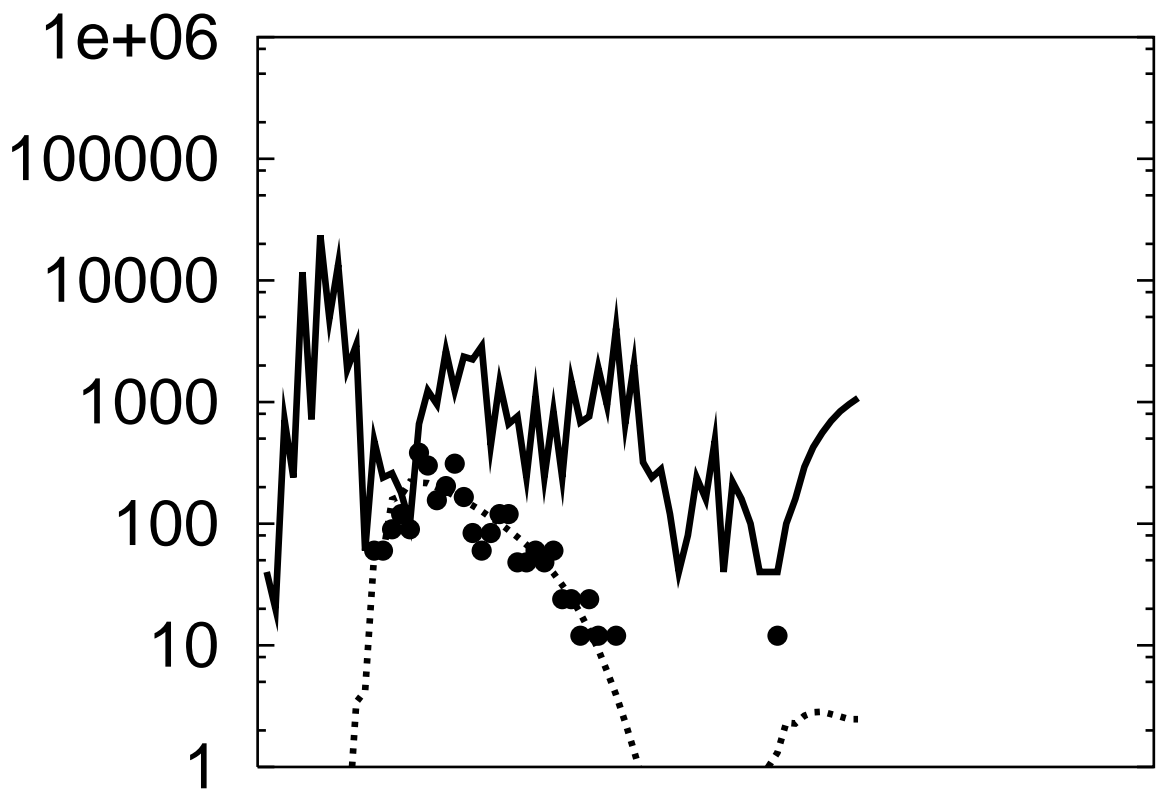
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



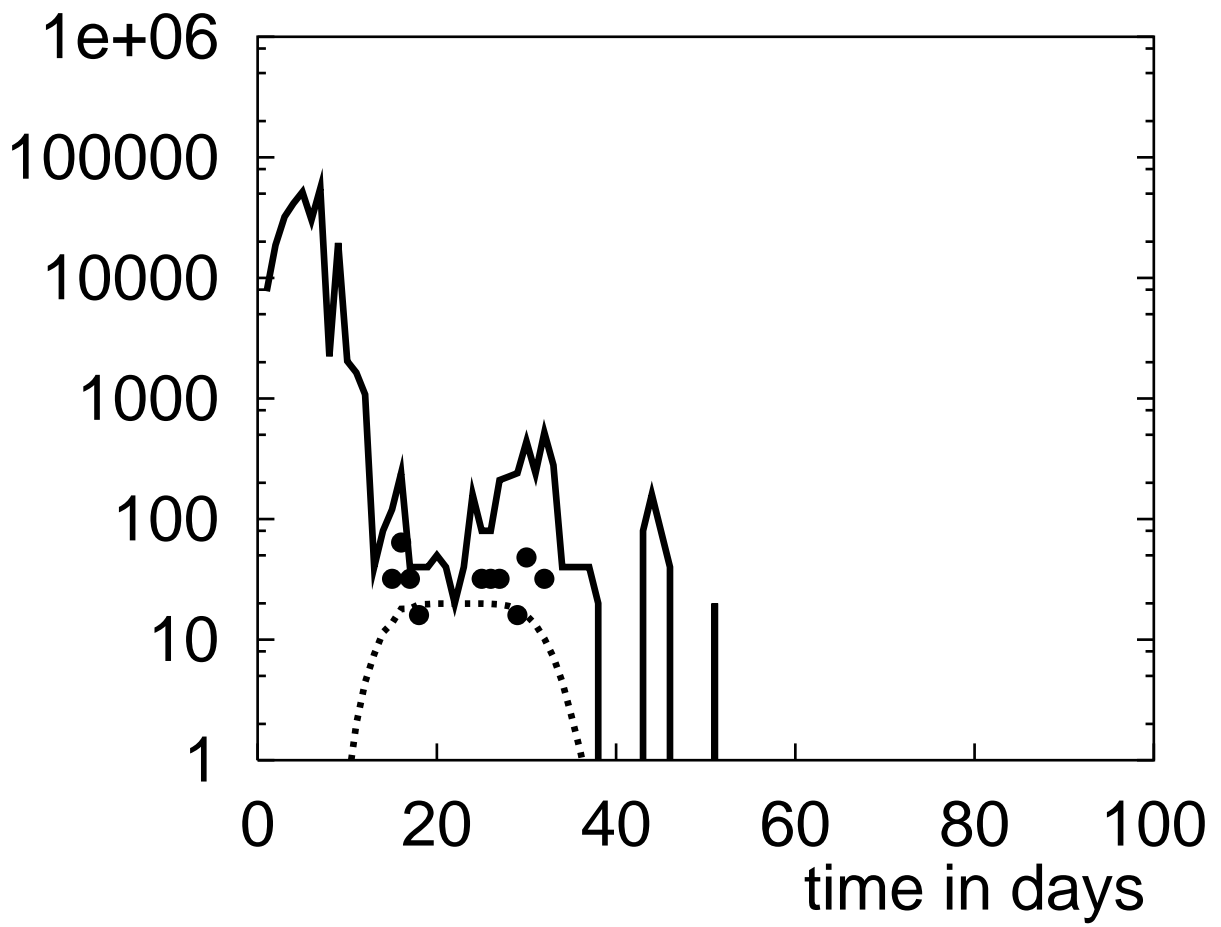
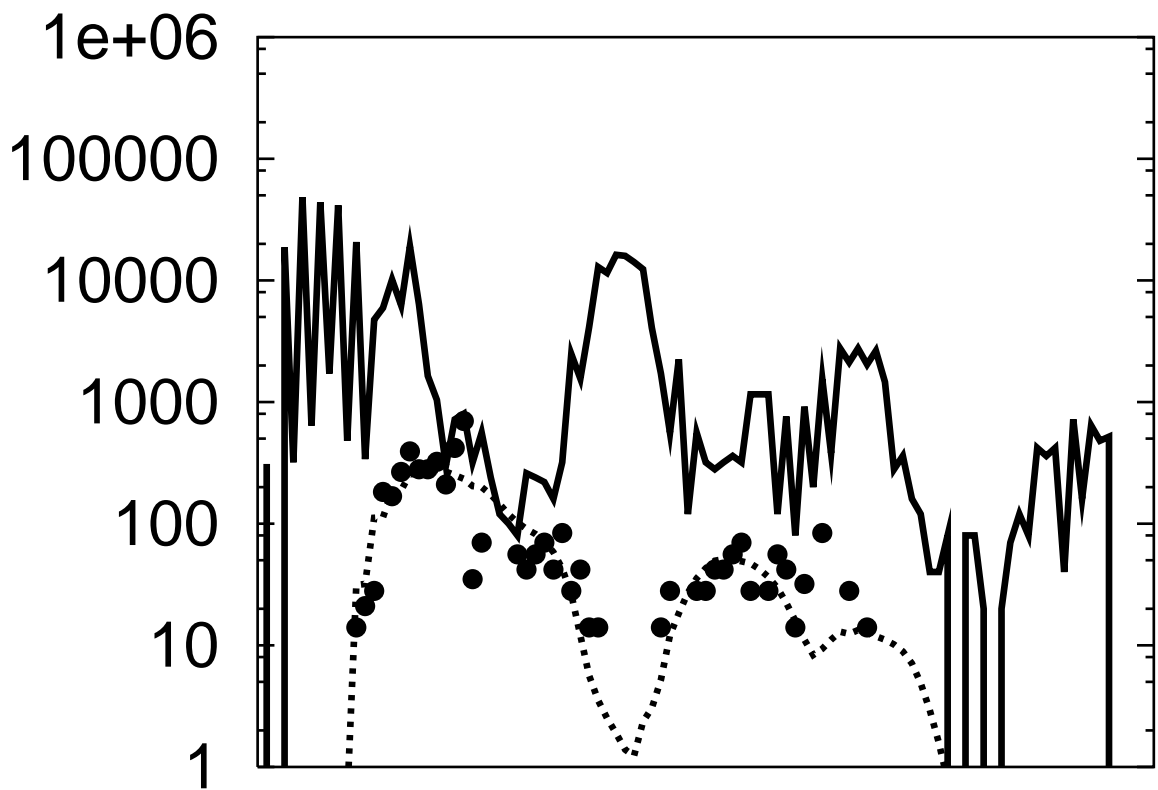
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



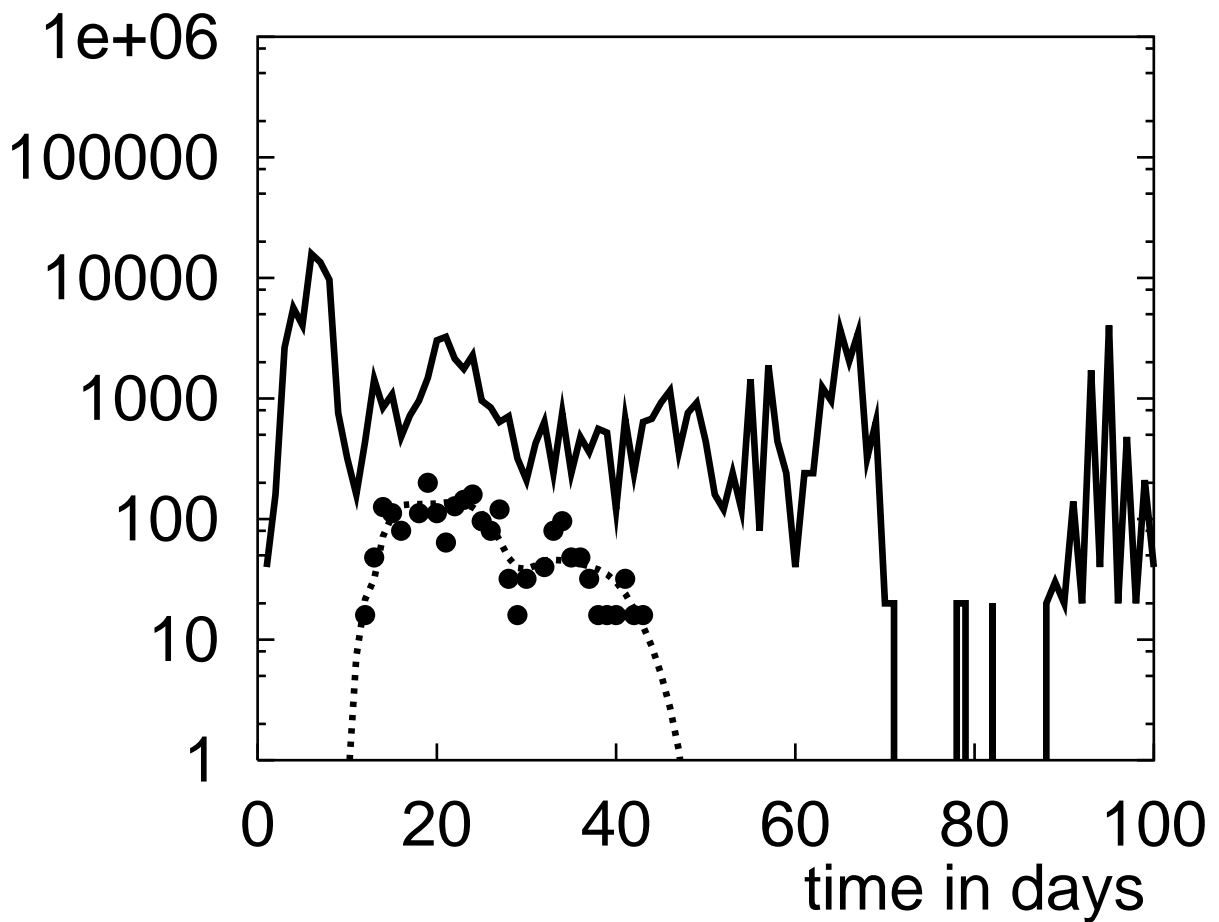
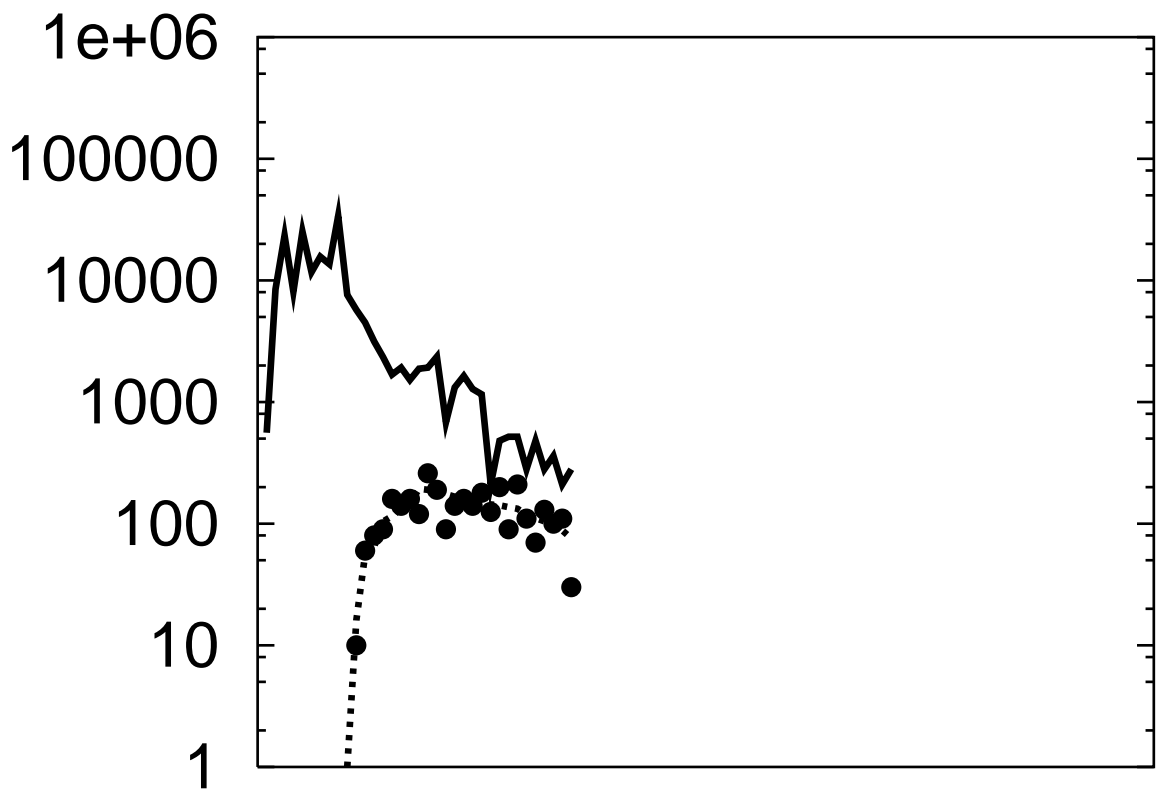
asex. parasites —————
observ. gameto. •
expect gameto. ······

parasites per μl blood



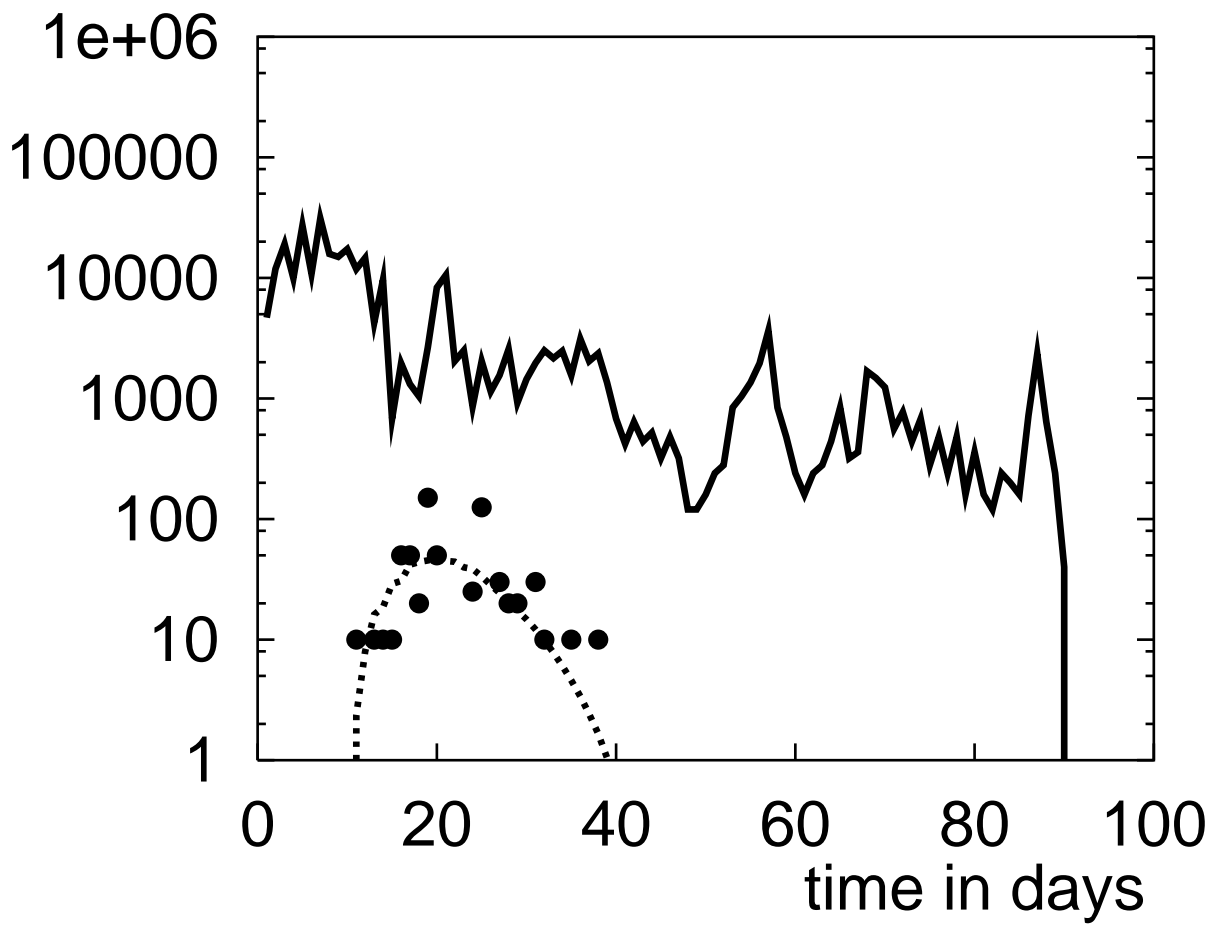
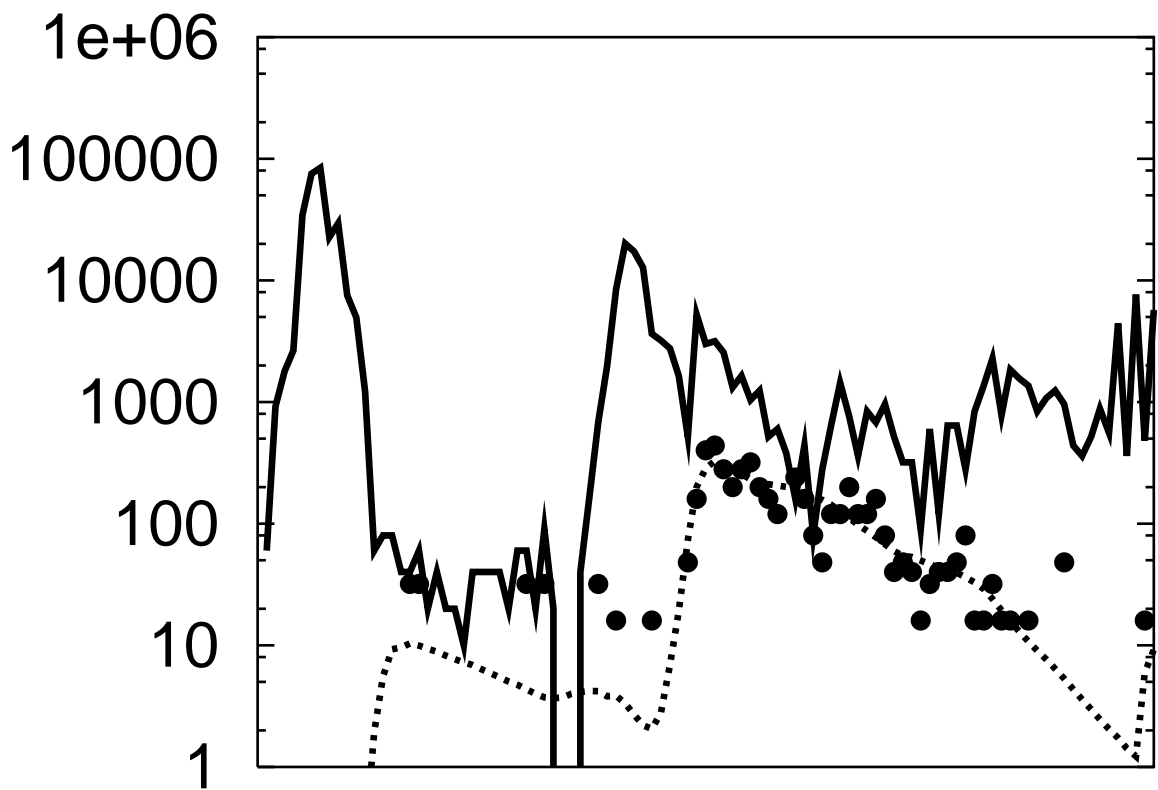
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



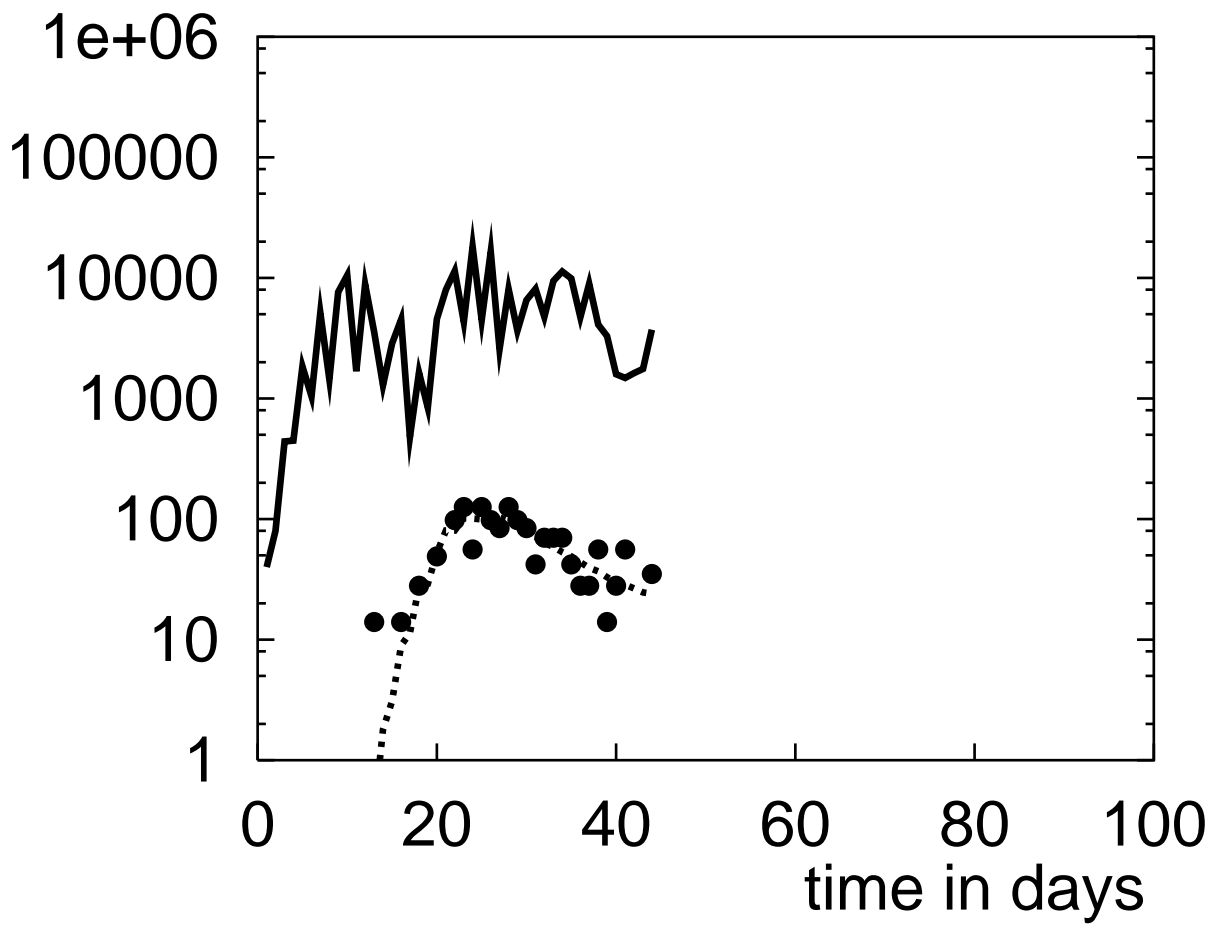
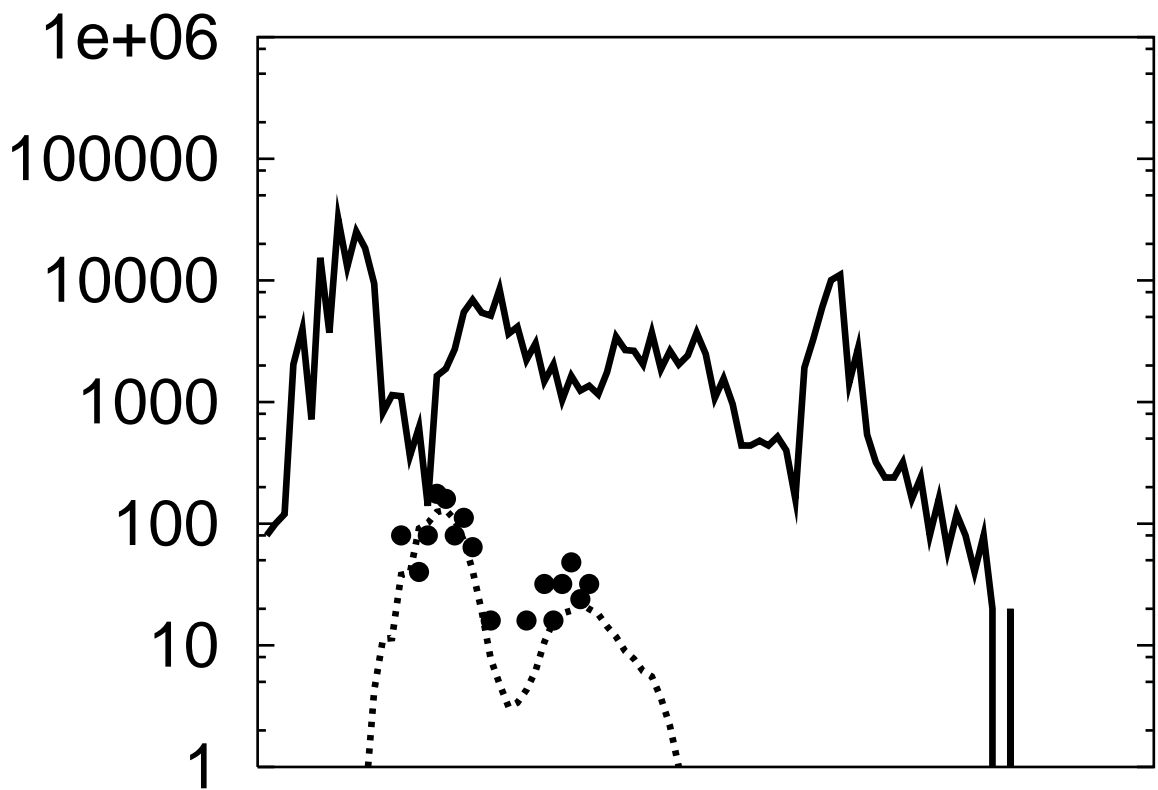
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



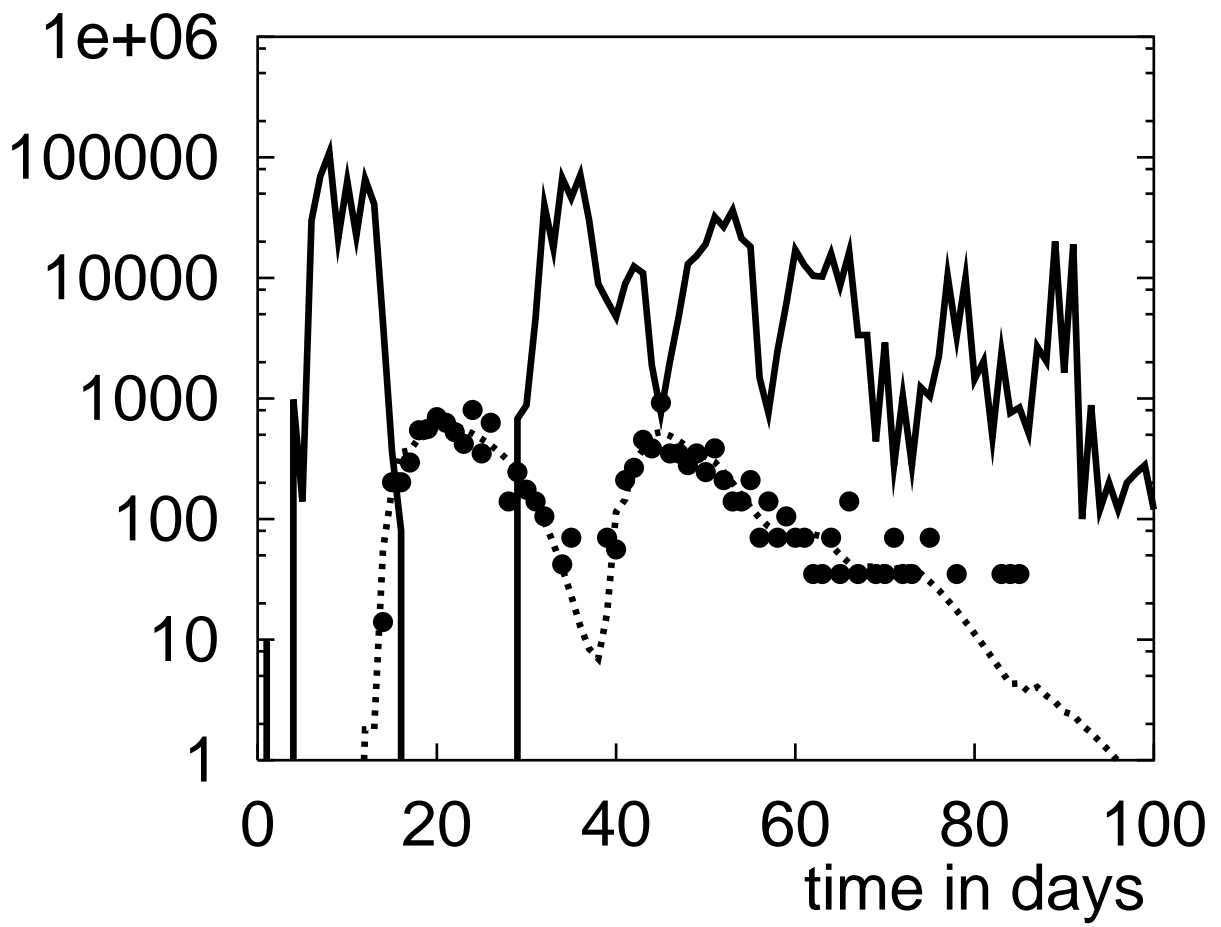
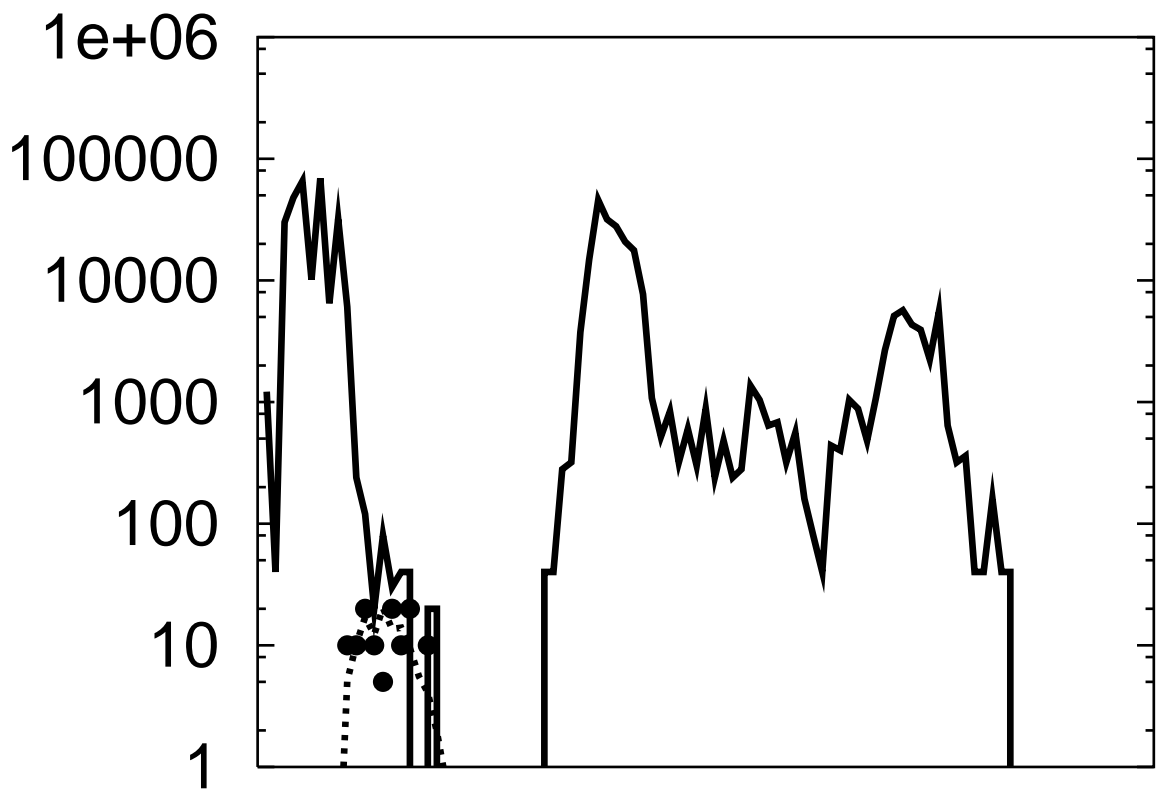
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



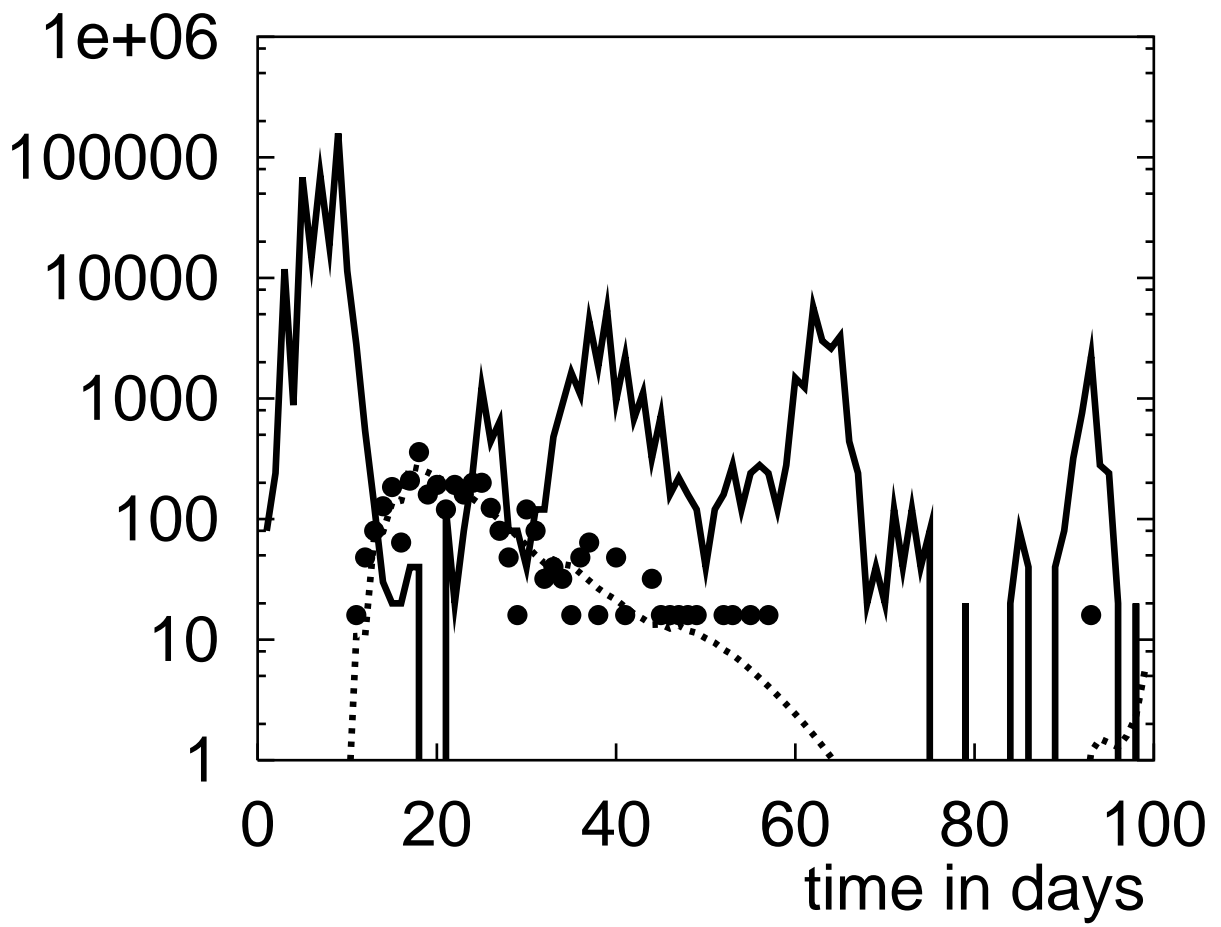
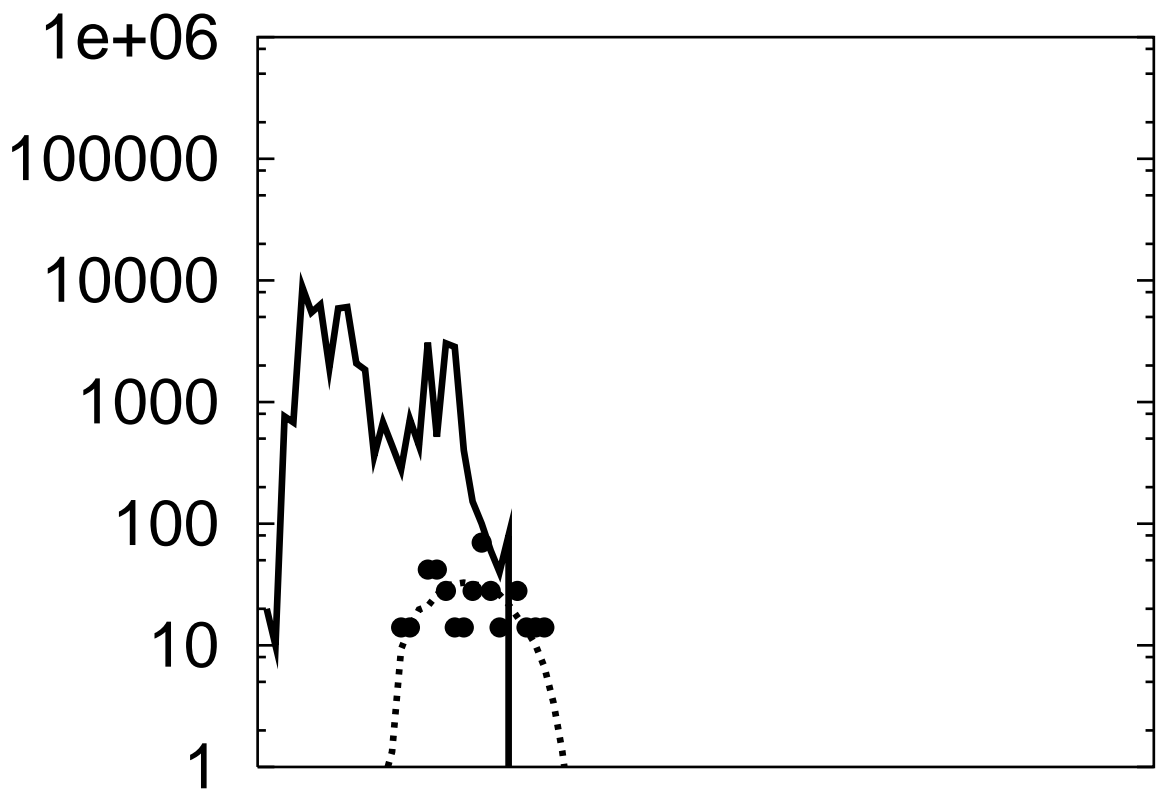
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



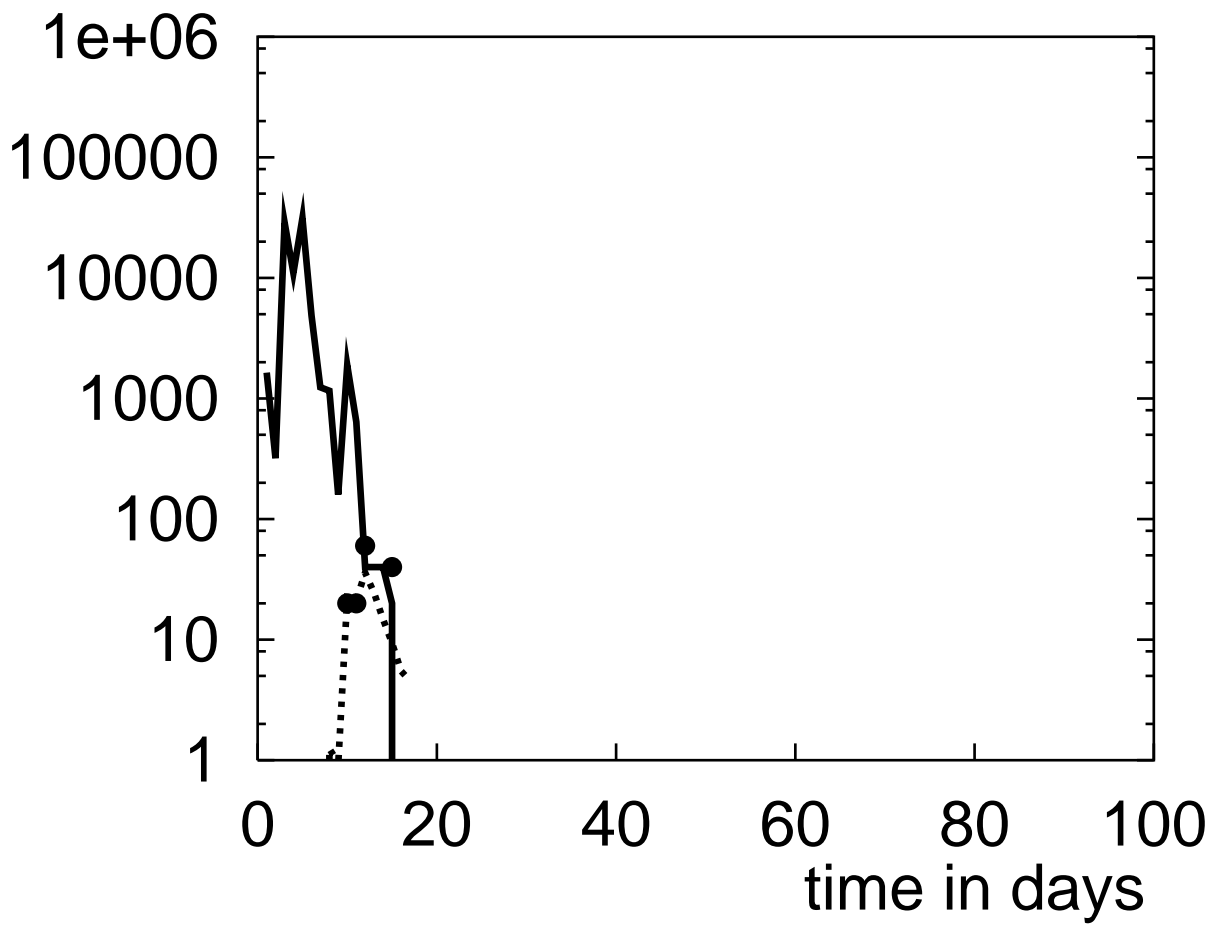
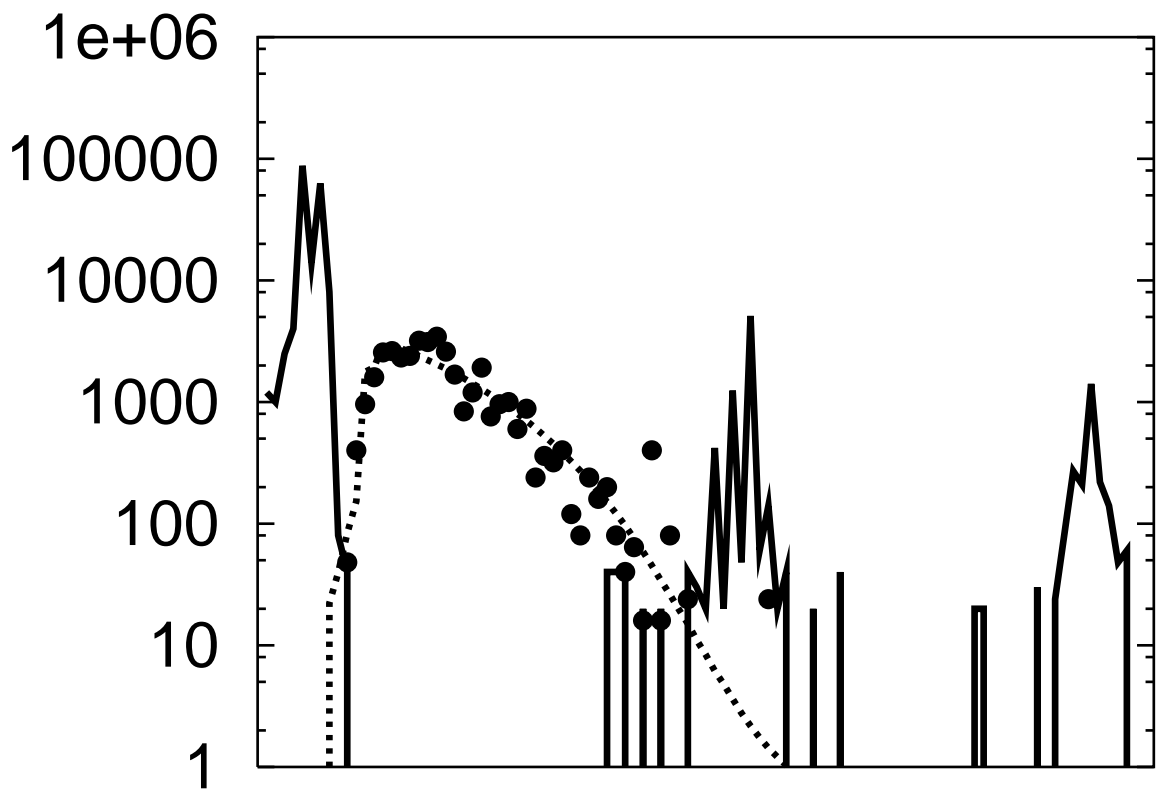
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



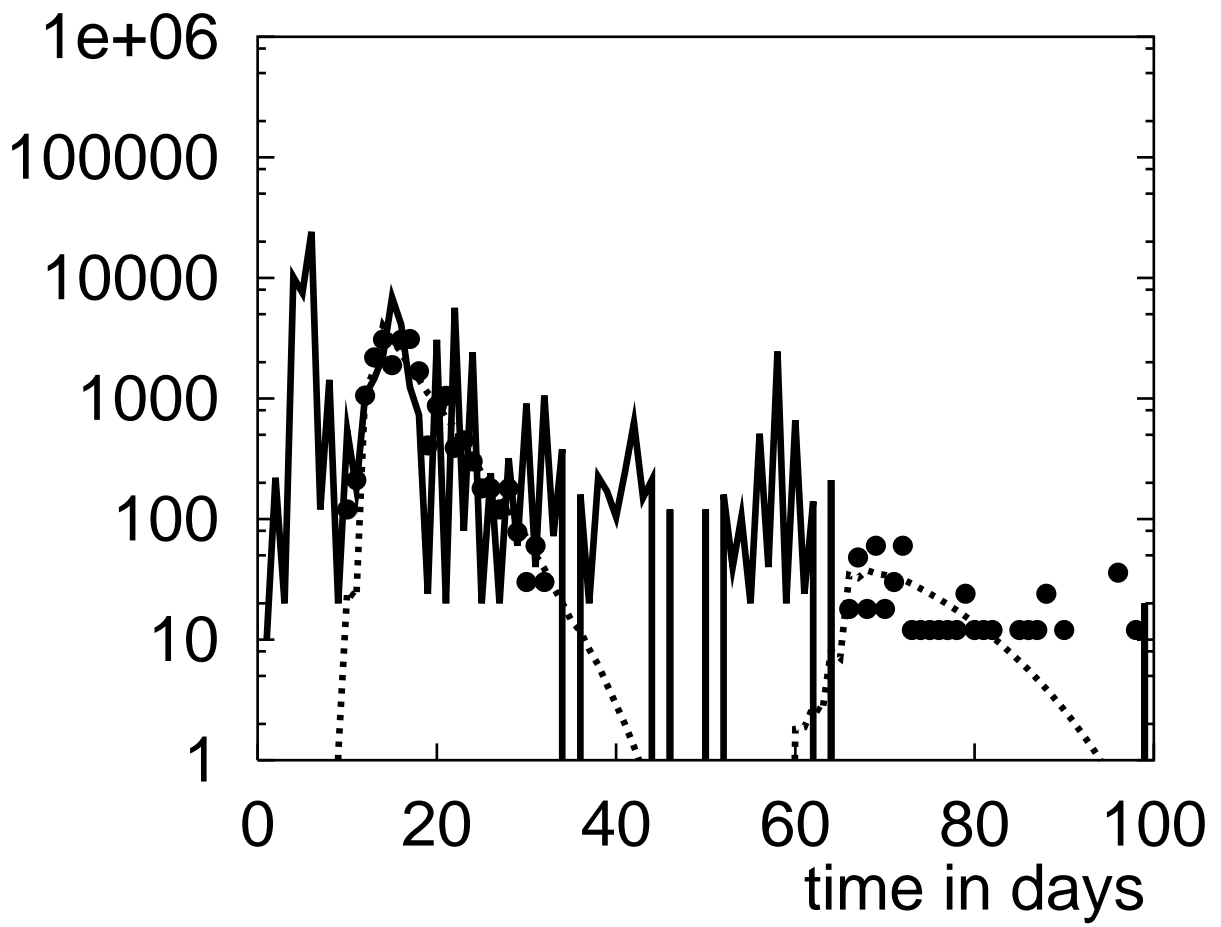
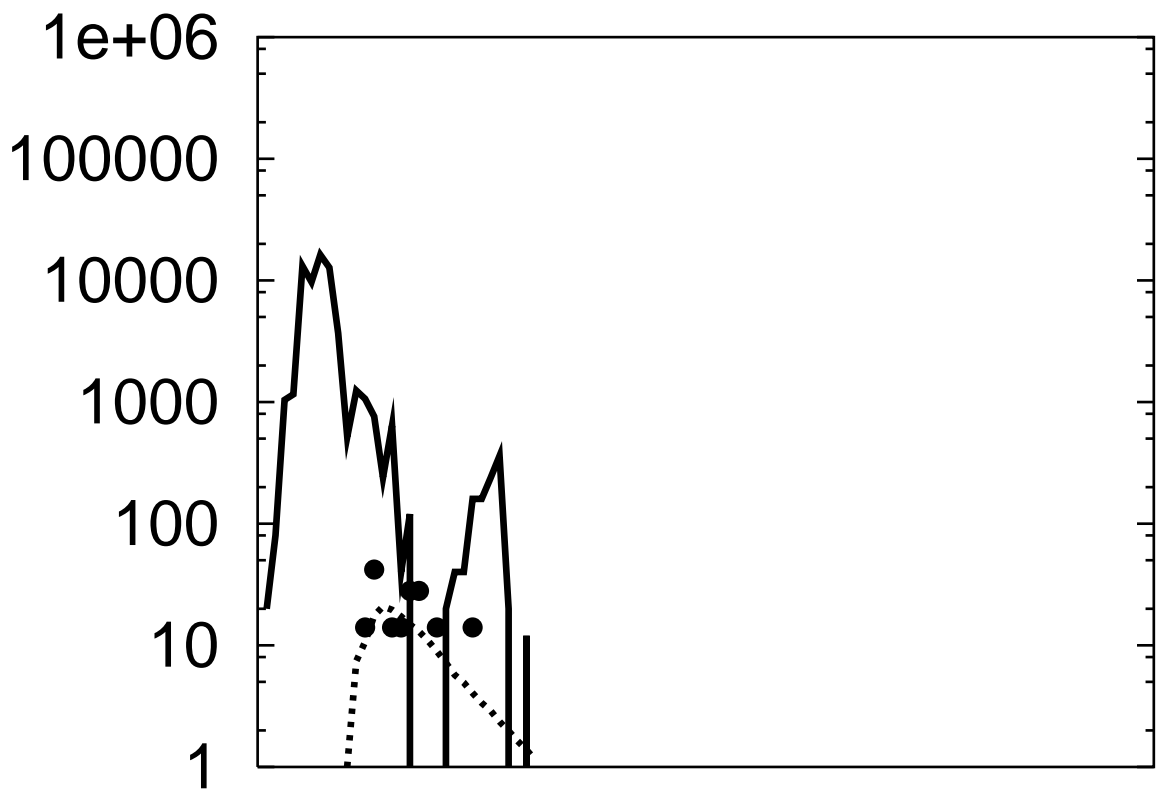
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



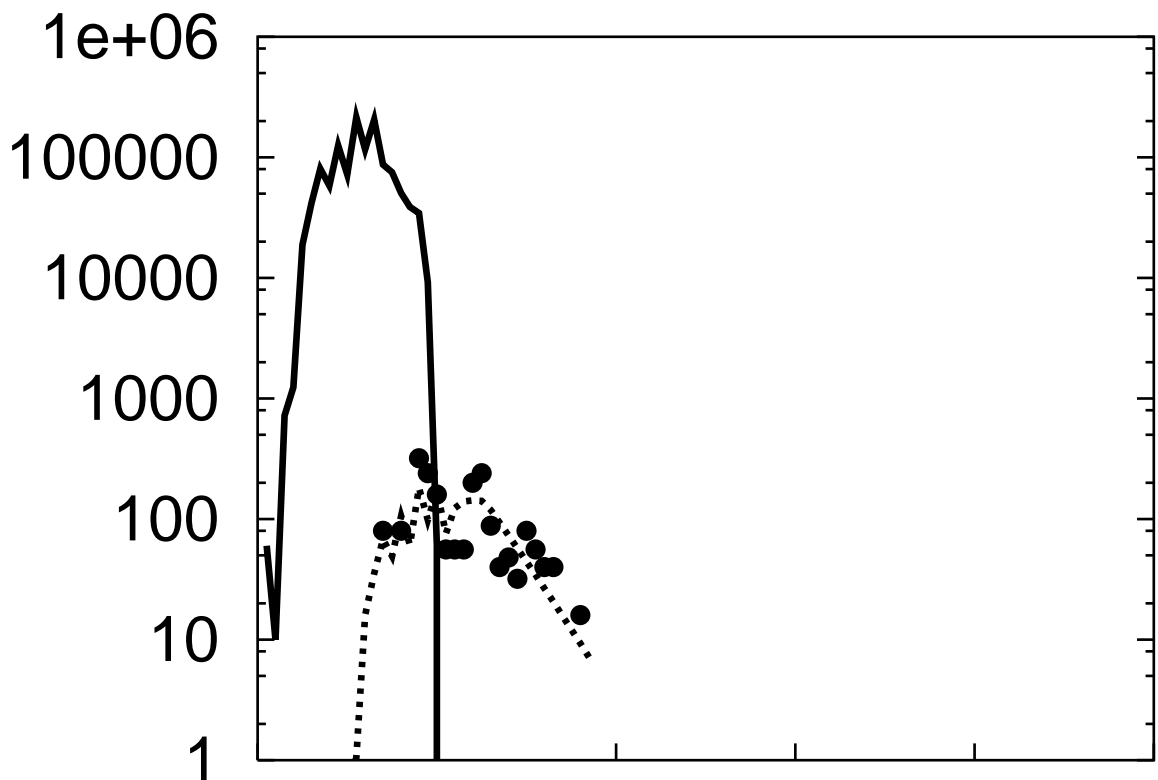
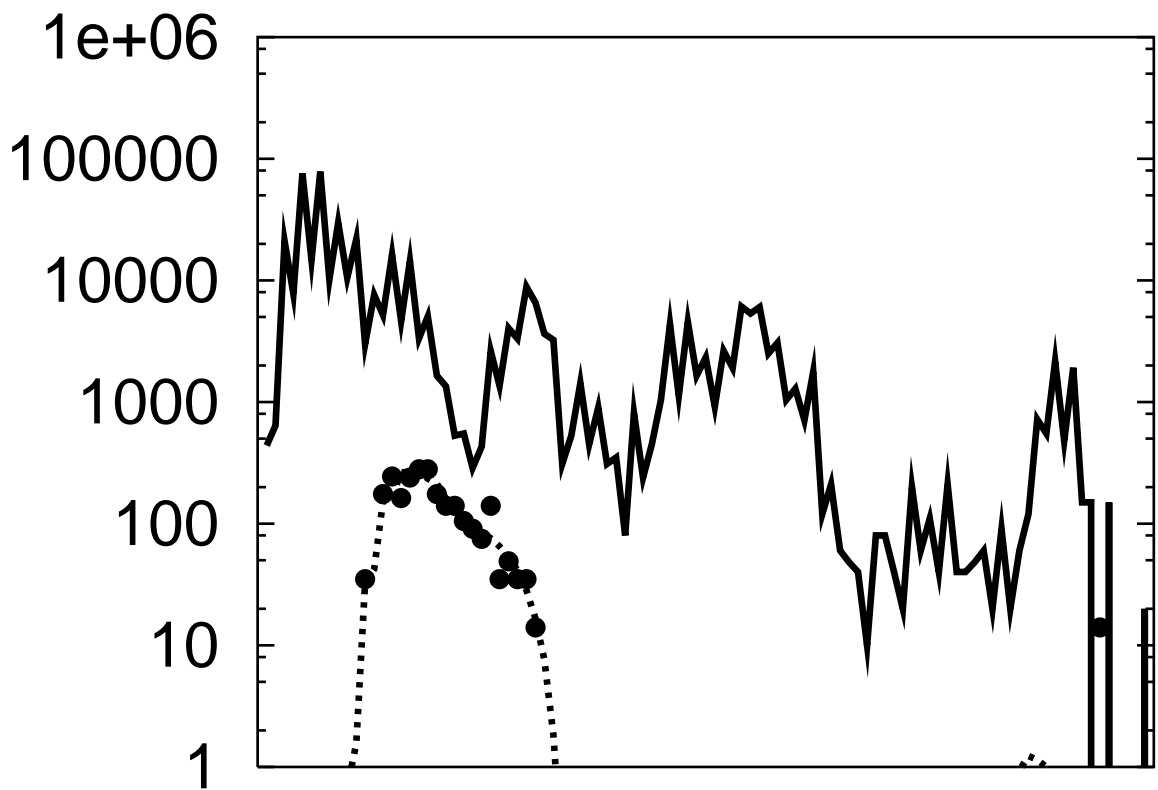
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



asex. parasites —
observ. gameto. •
expect gameto. ···

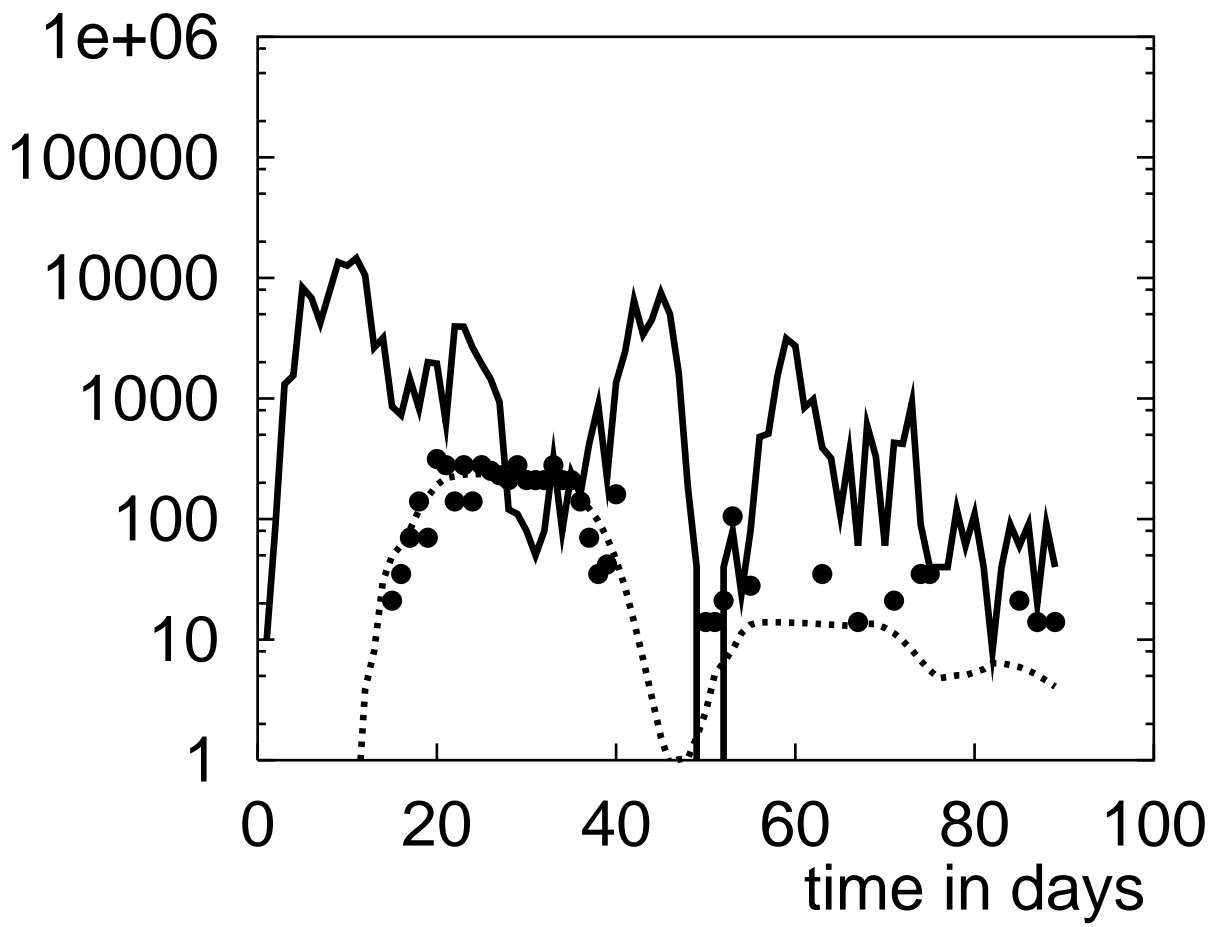
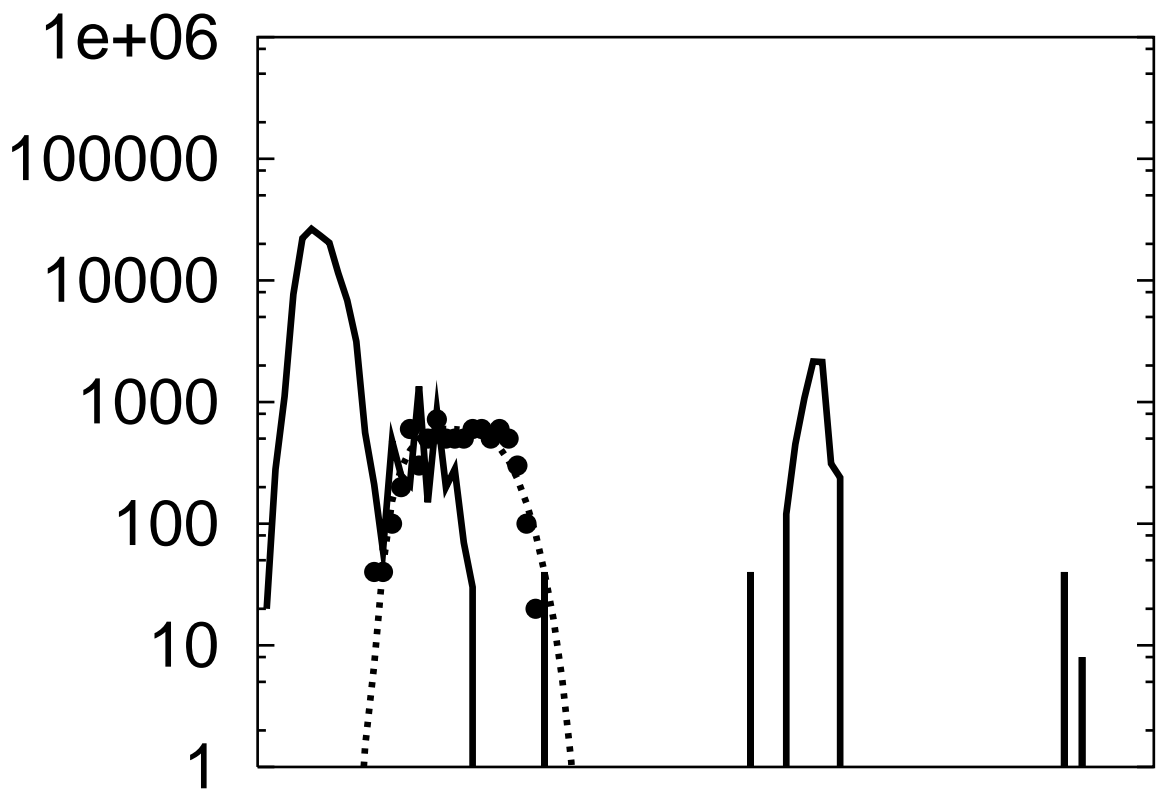
parasites per μl blood



0 20 40 60 80 100
time in days

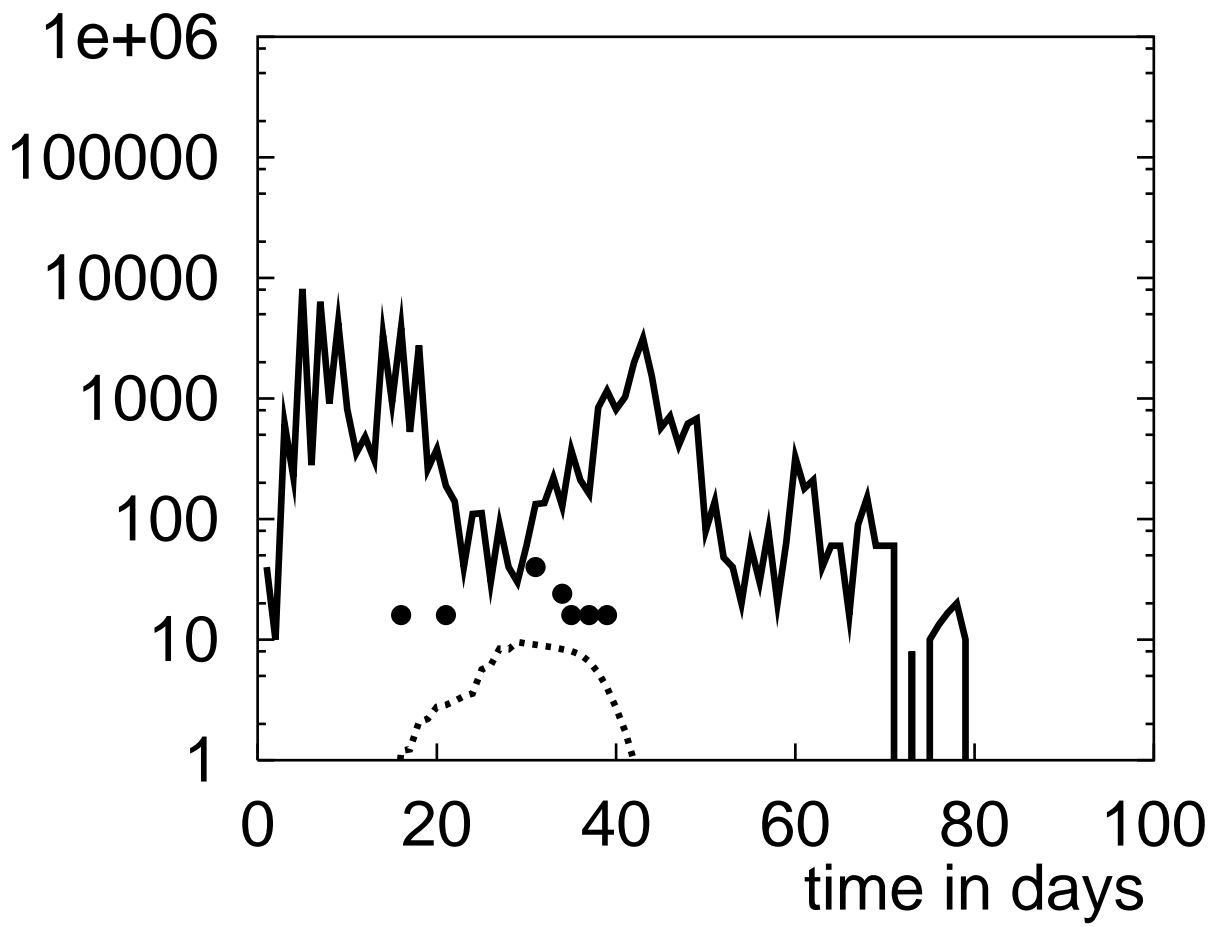
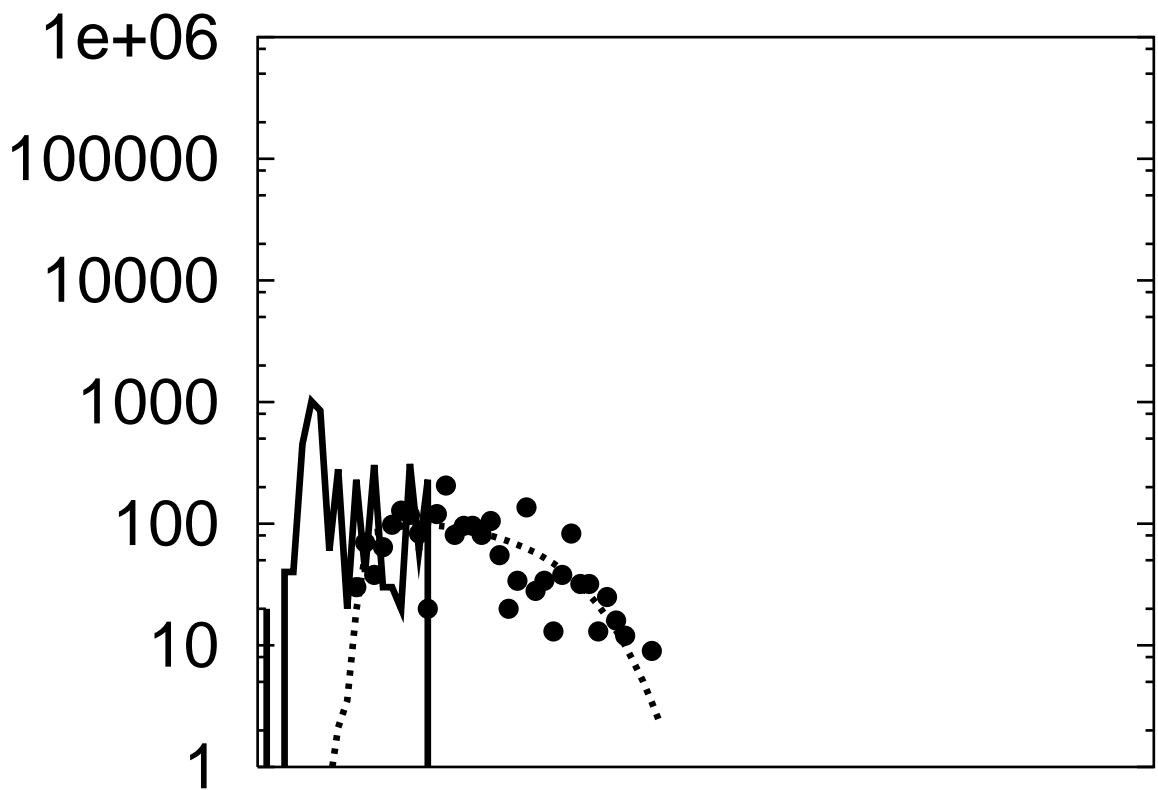
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



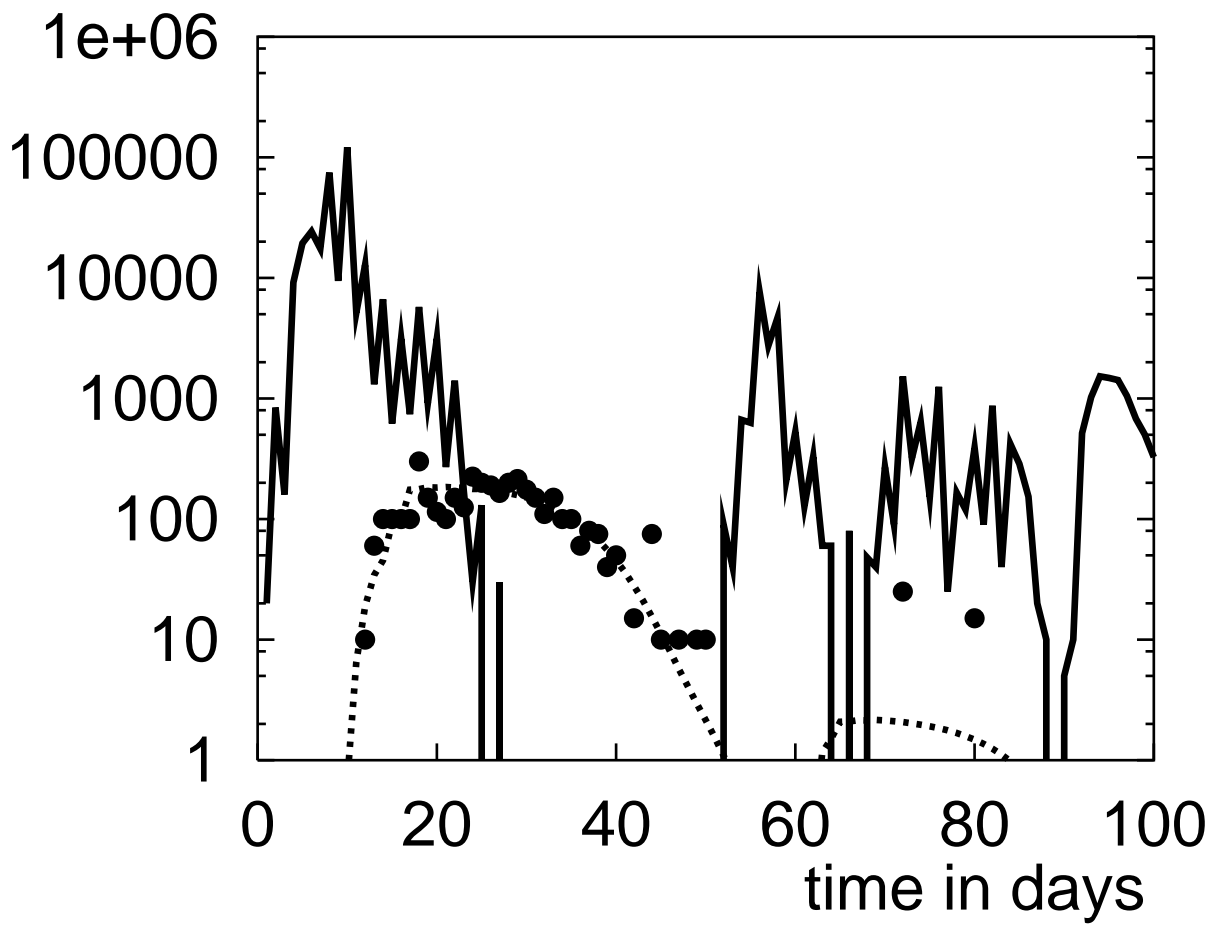
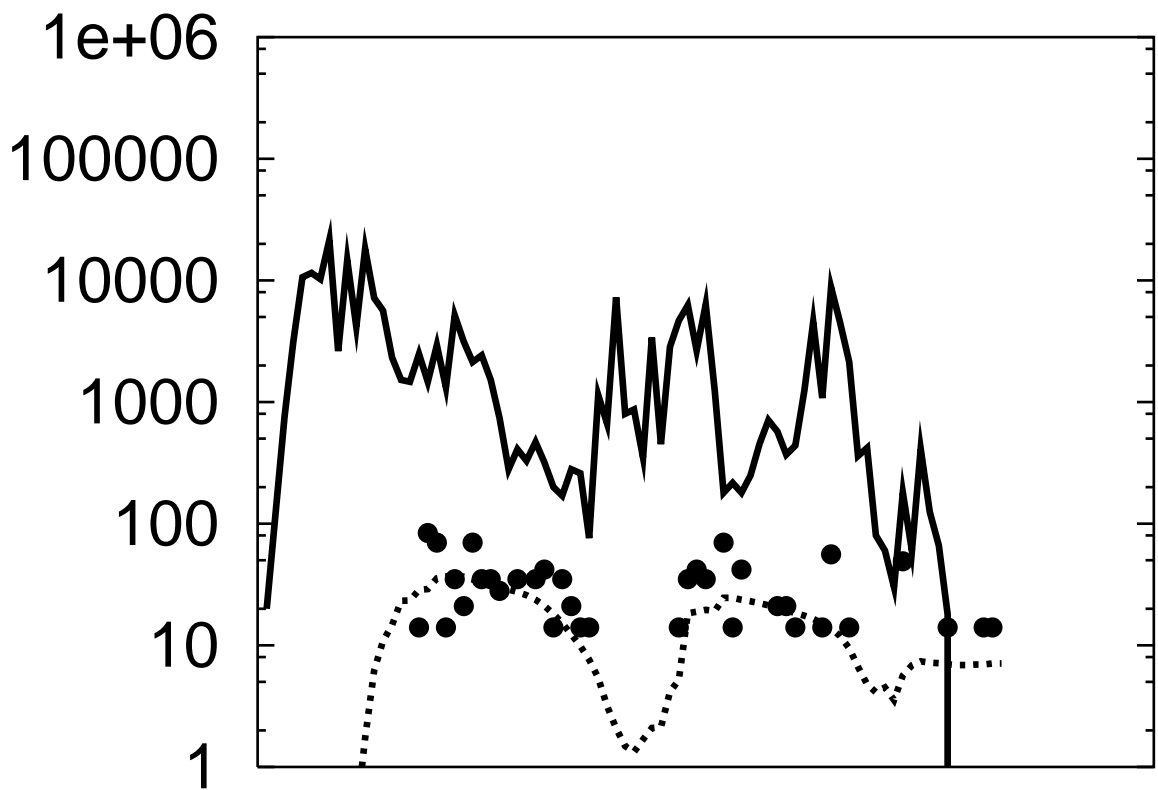
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



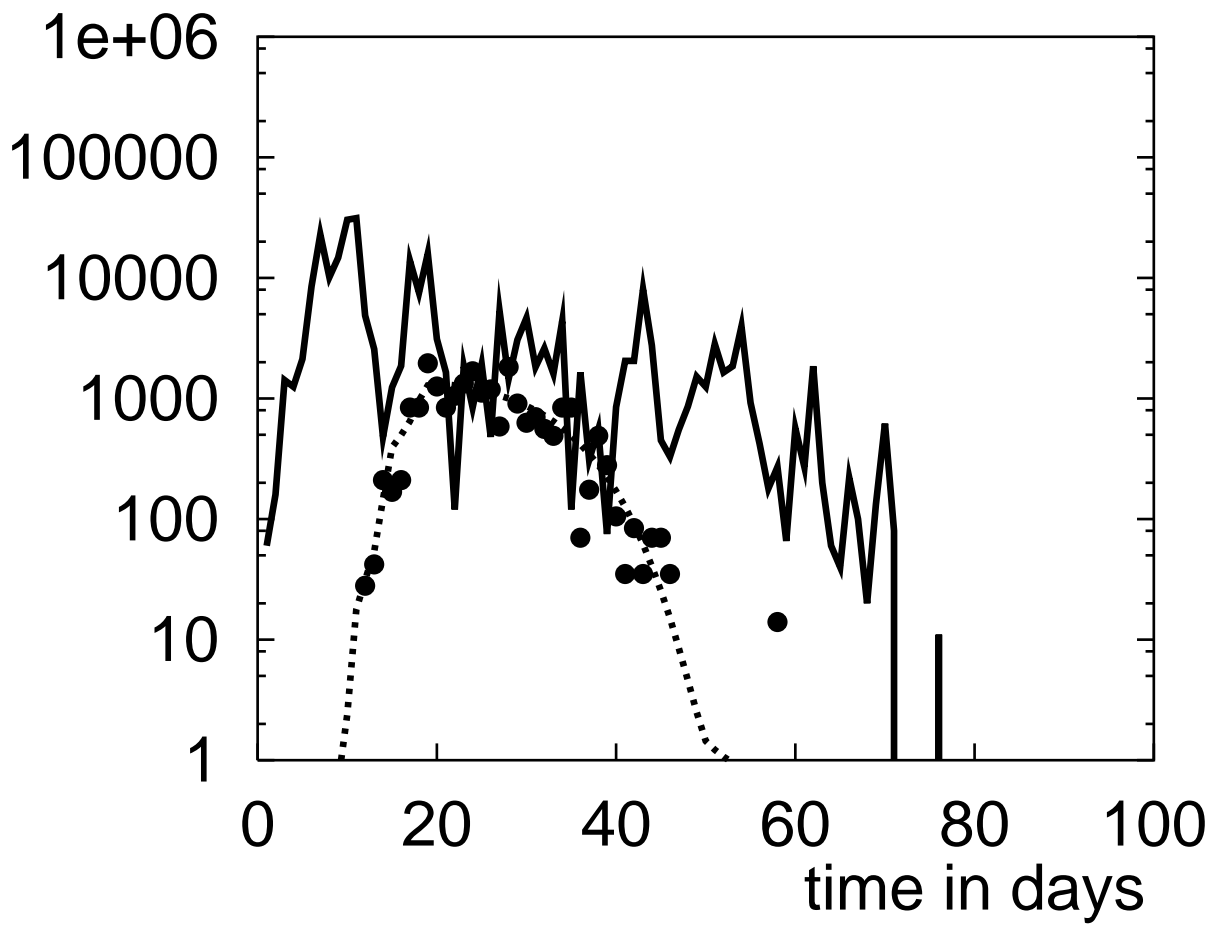
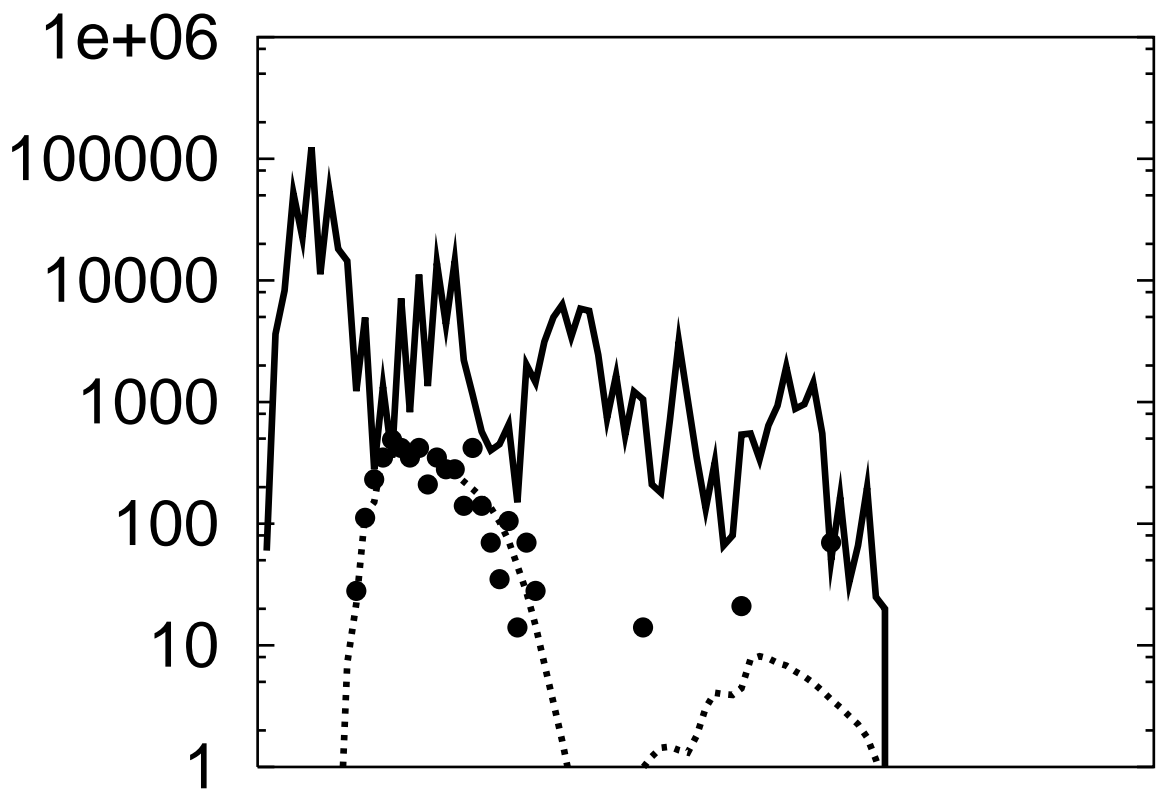
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



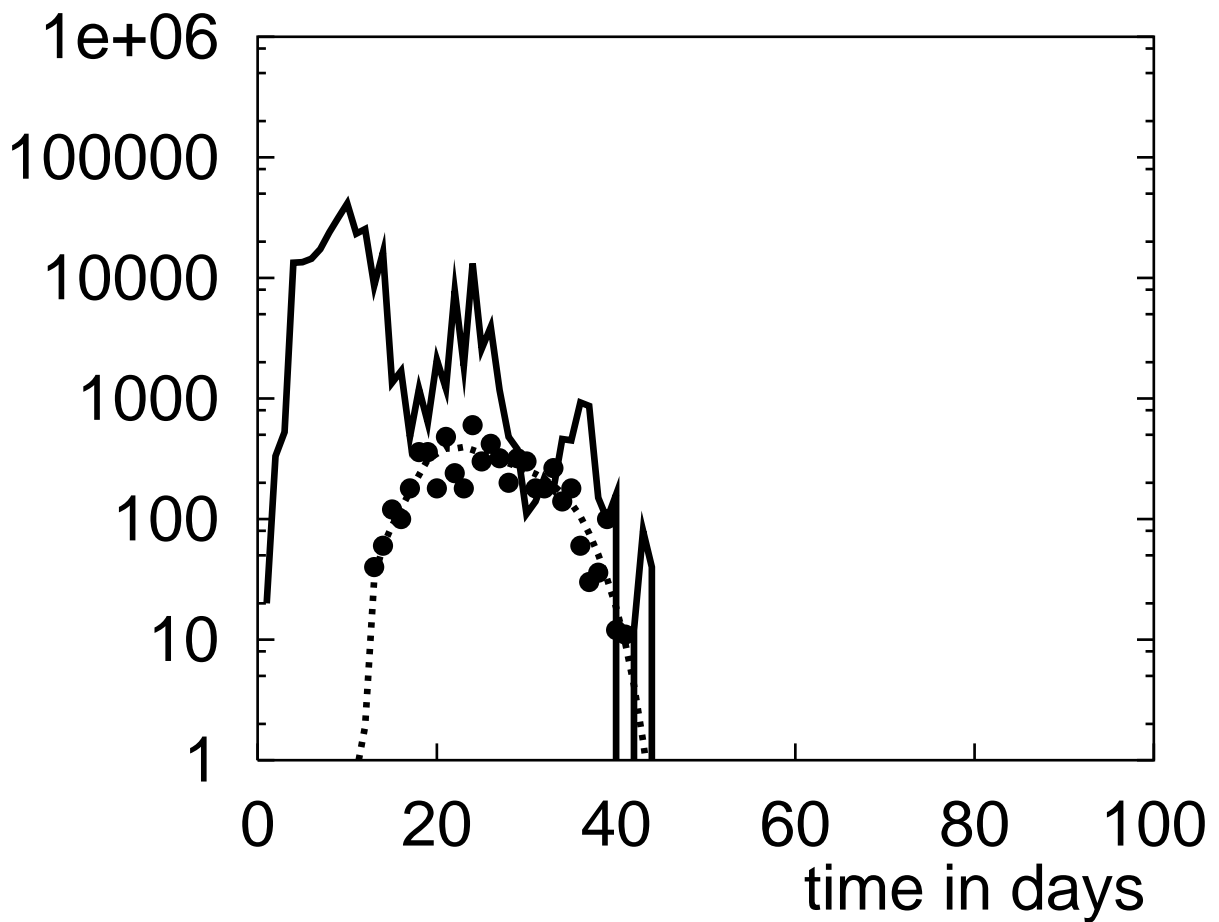
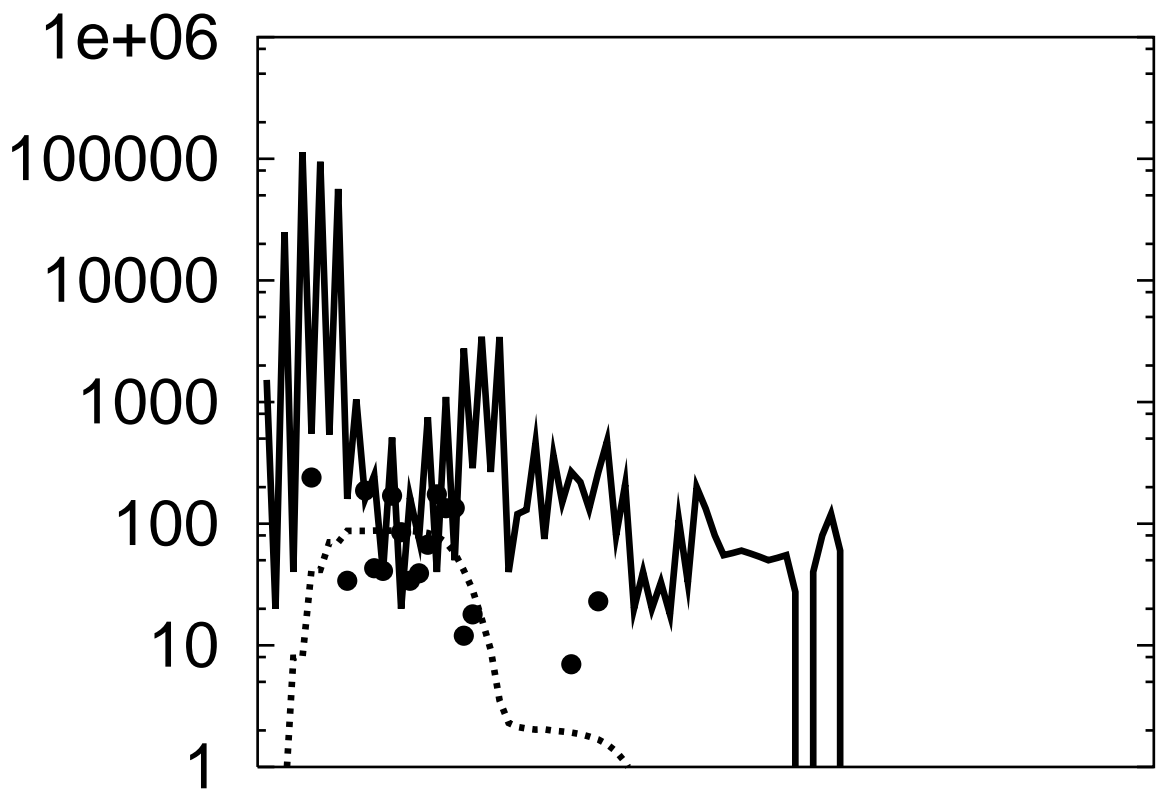
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



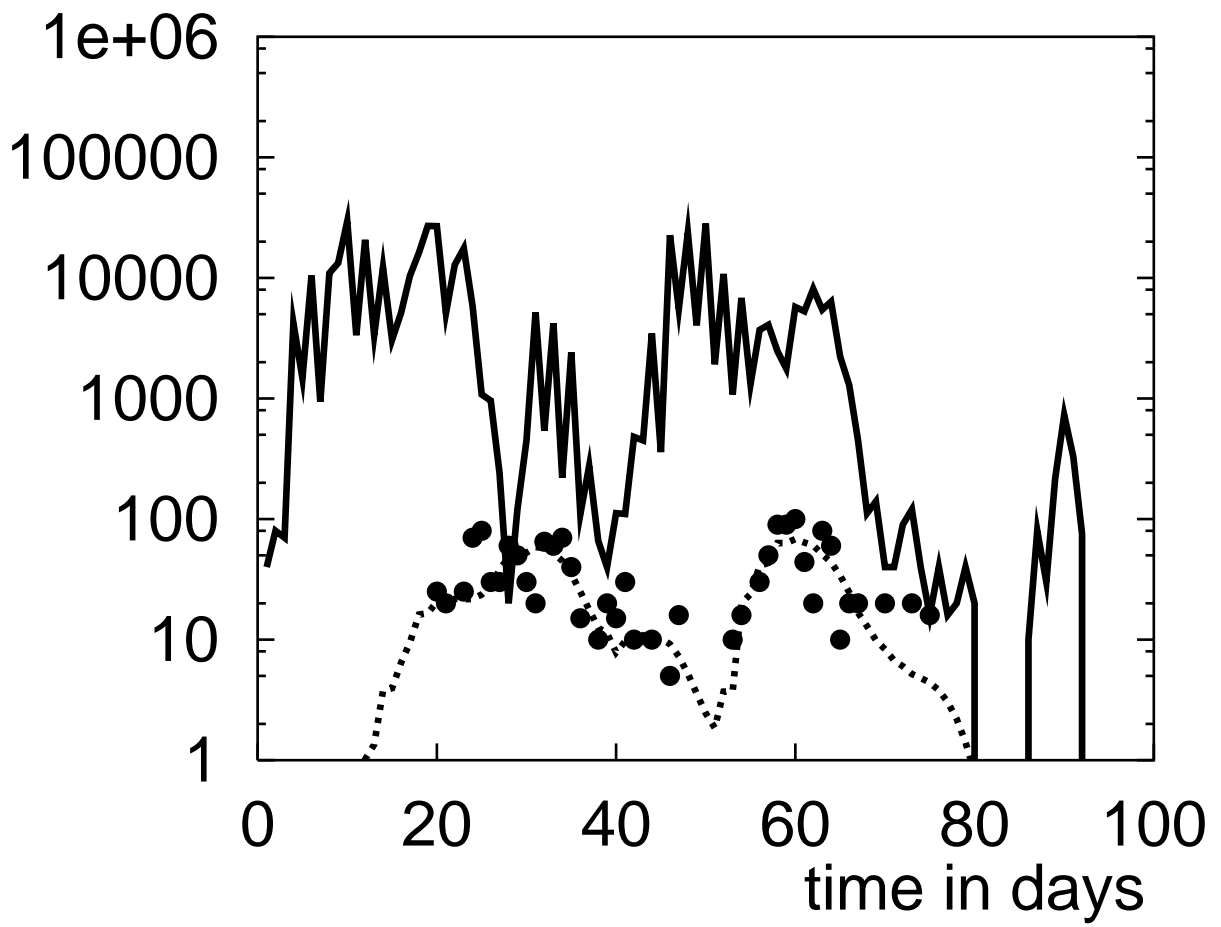
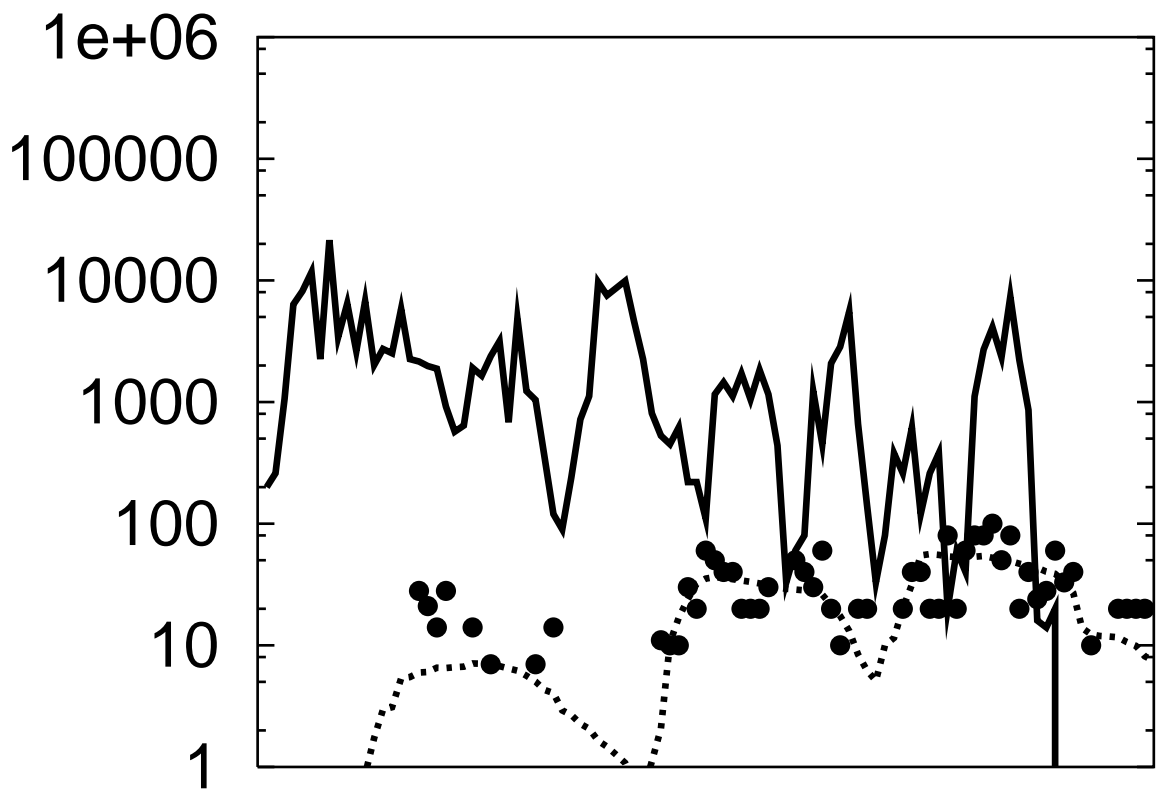
asex. parasites —
observ. gameto. •
expect gameto. ·····

parasites per μl blood



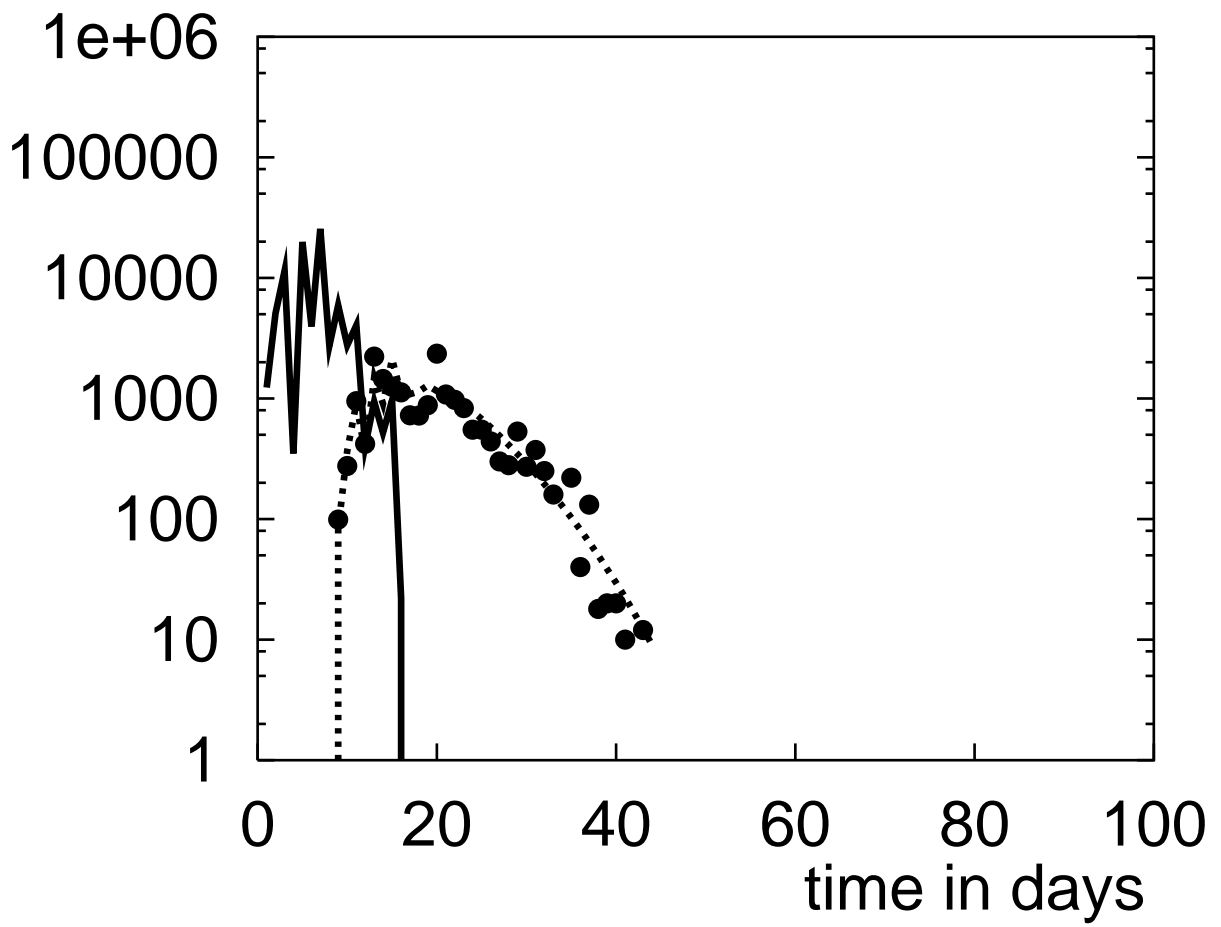
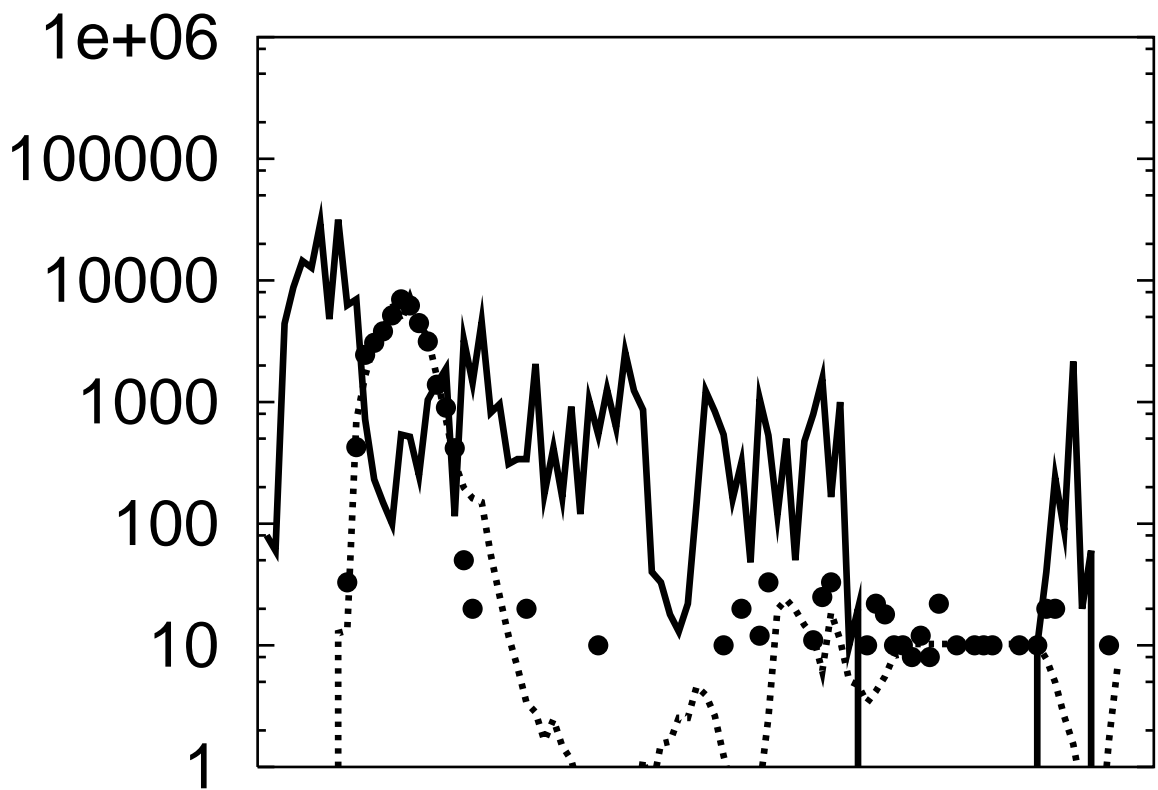
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



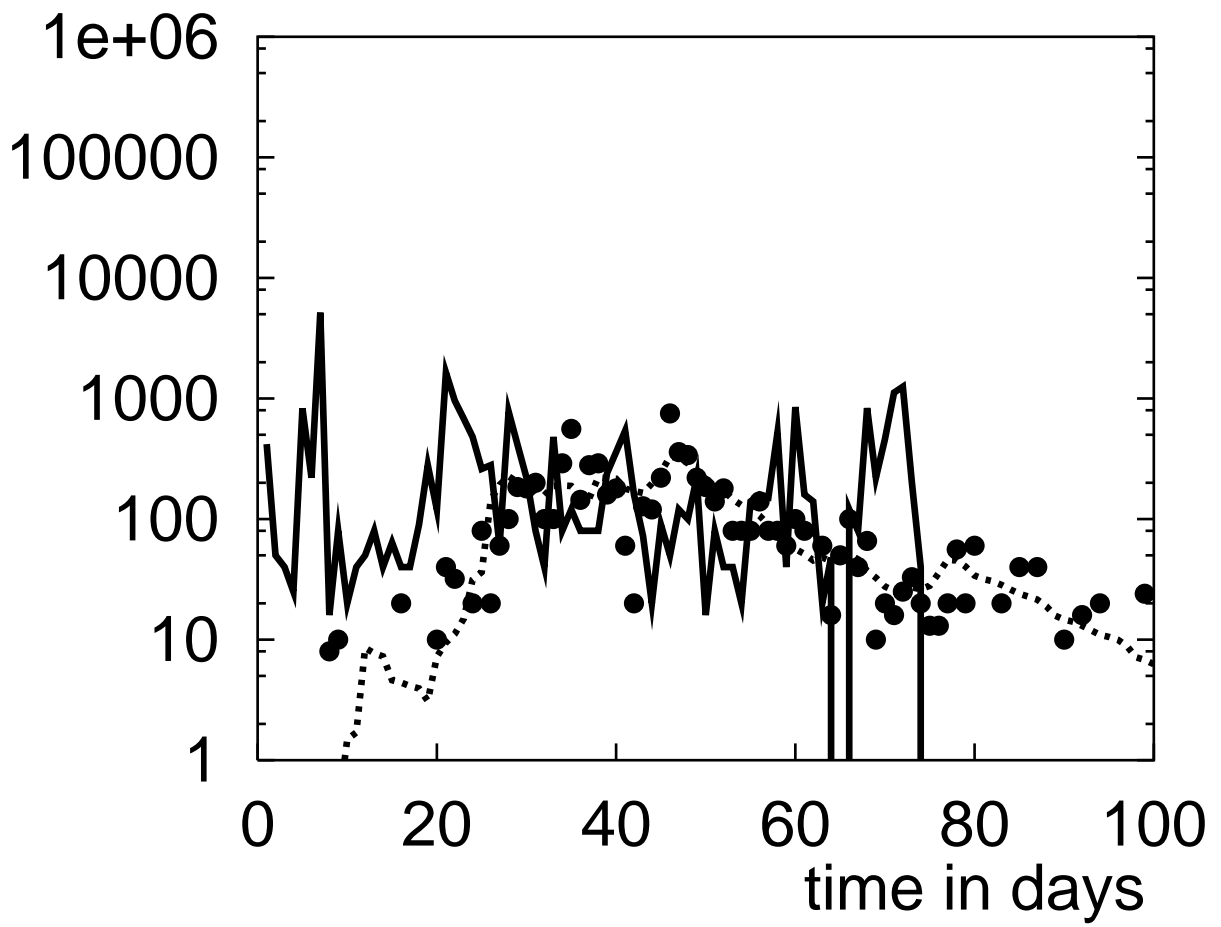
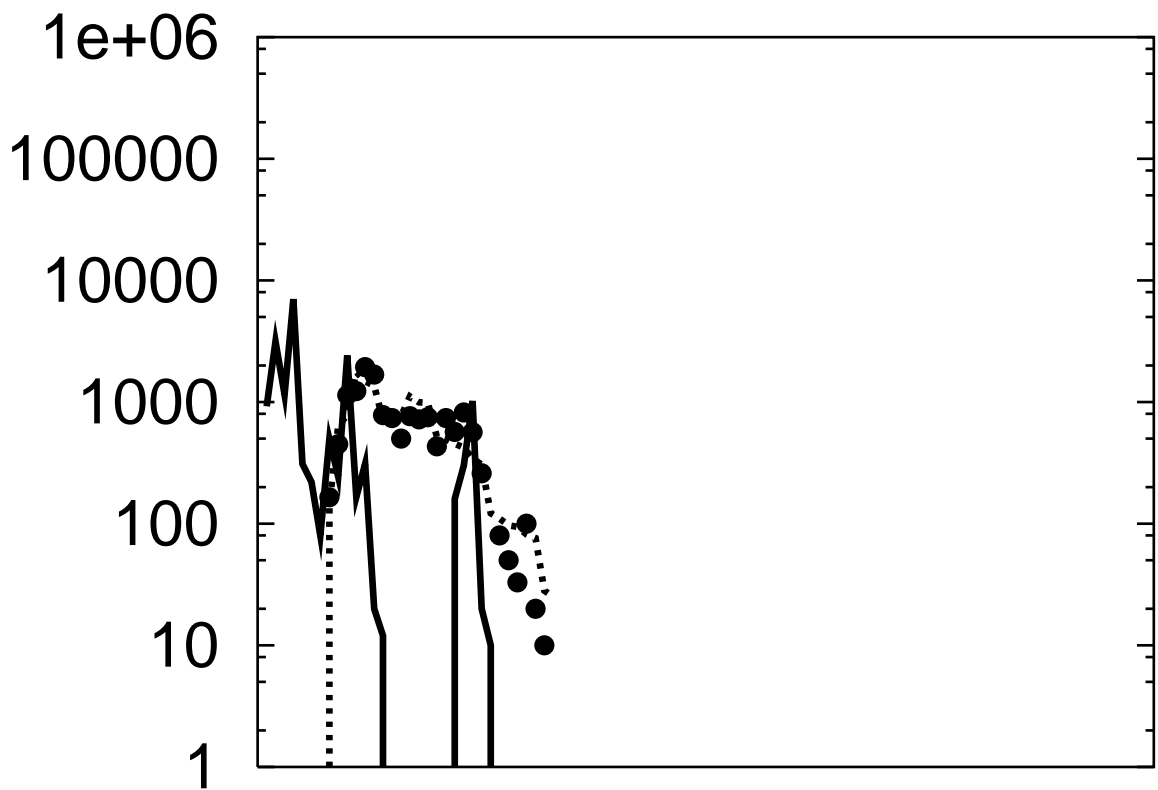
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



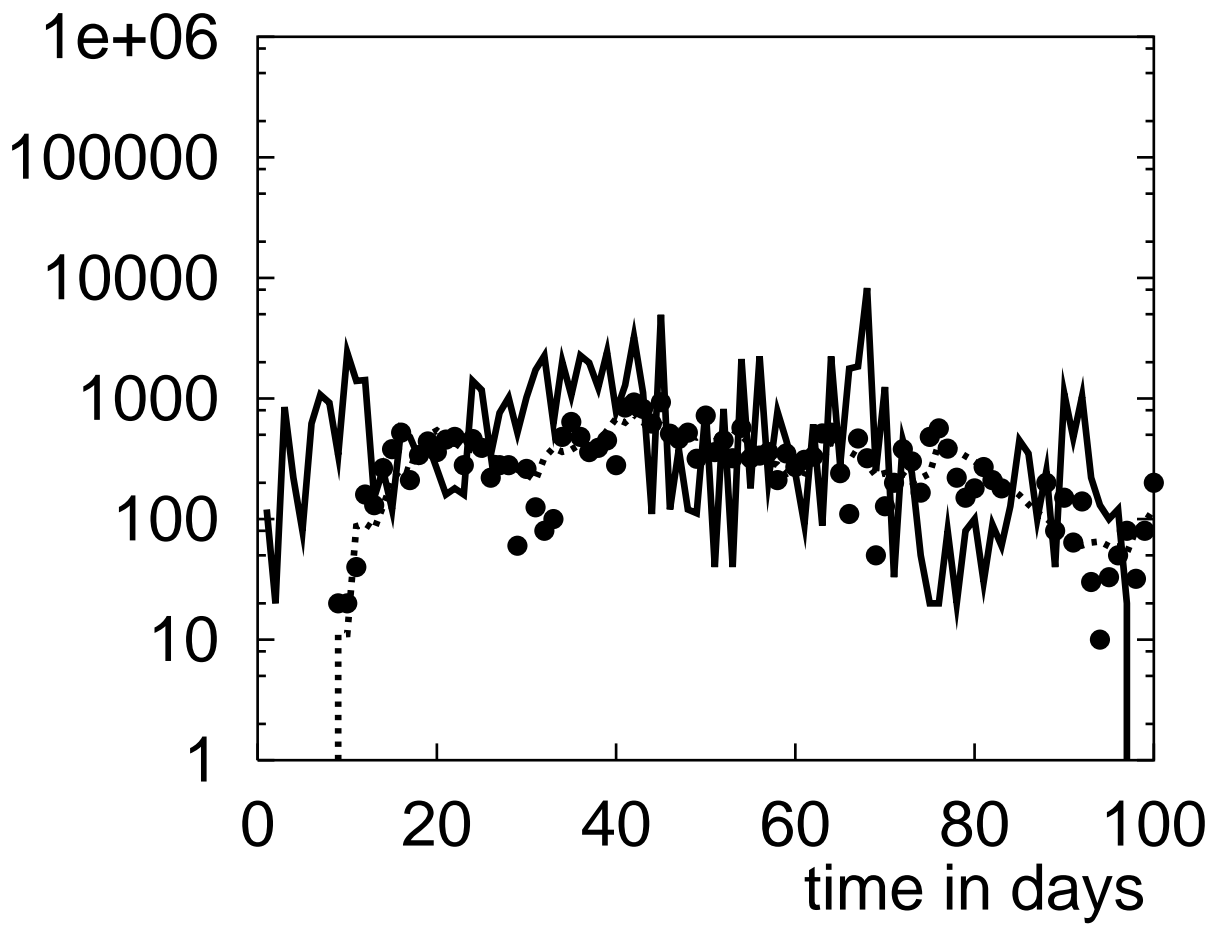
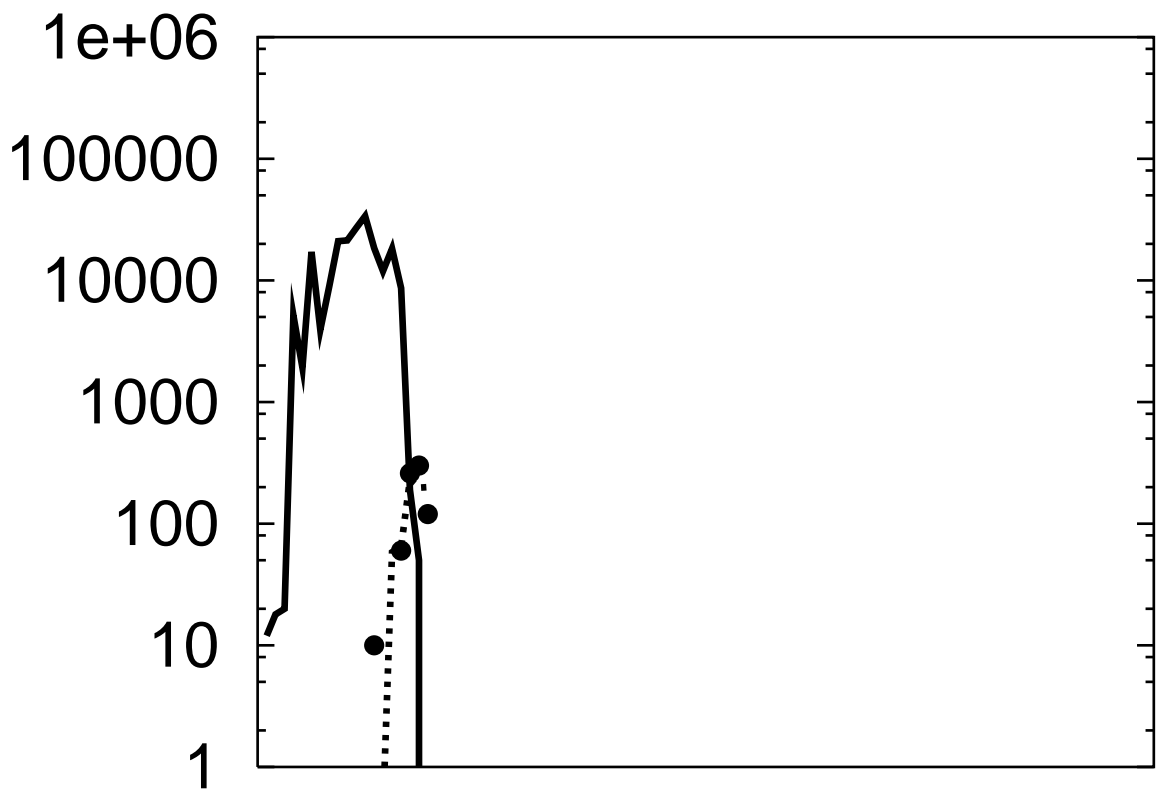
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



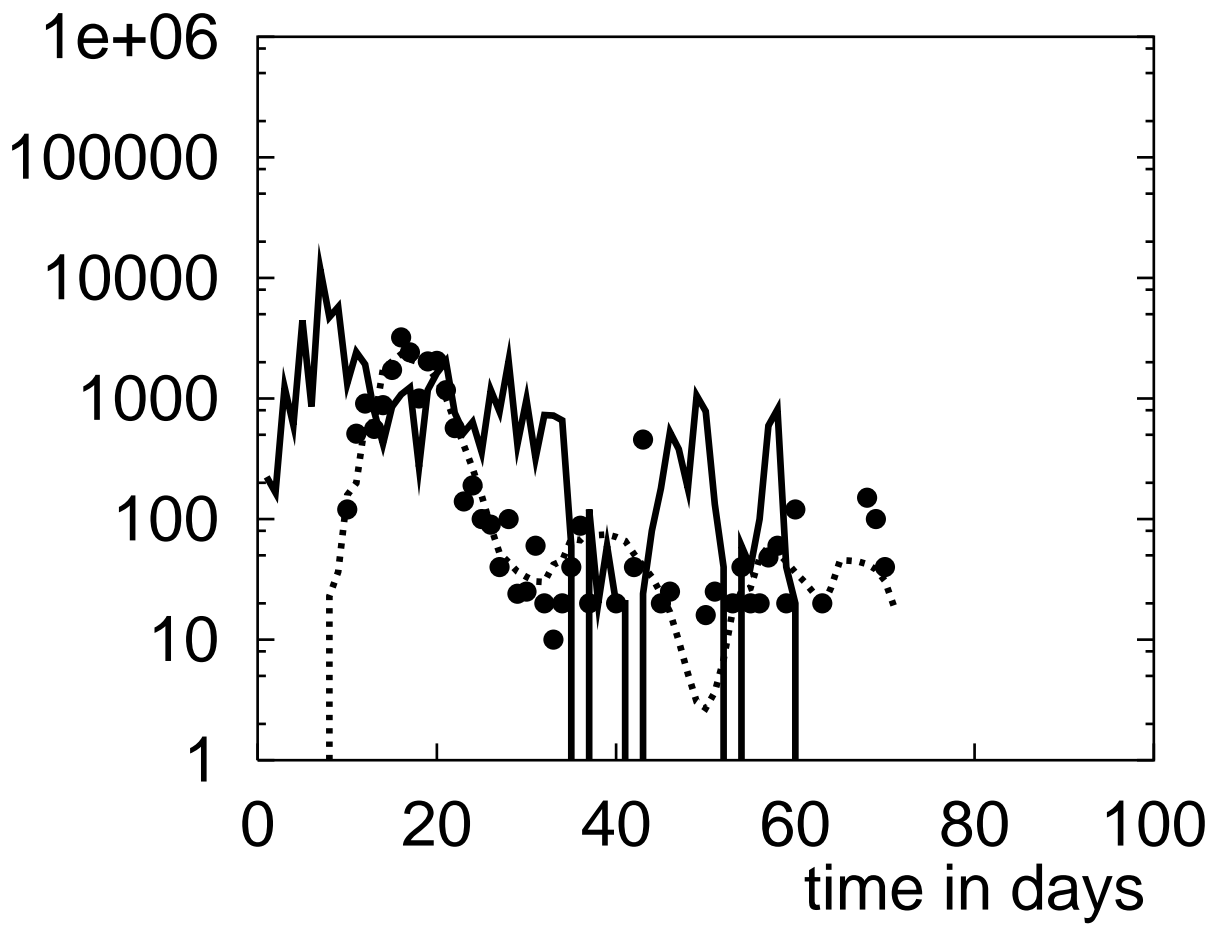
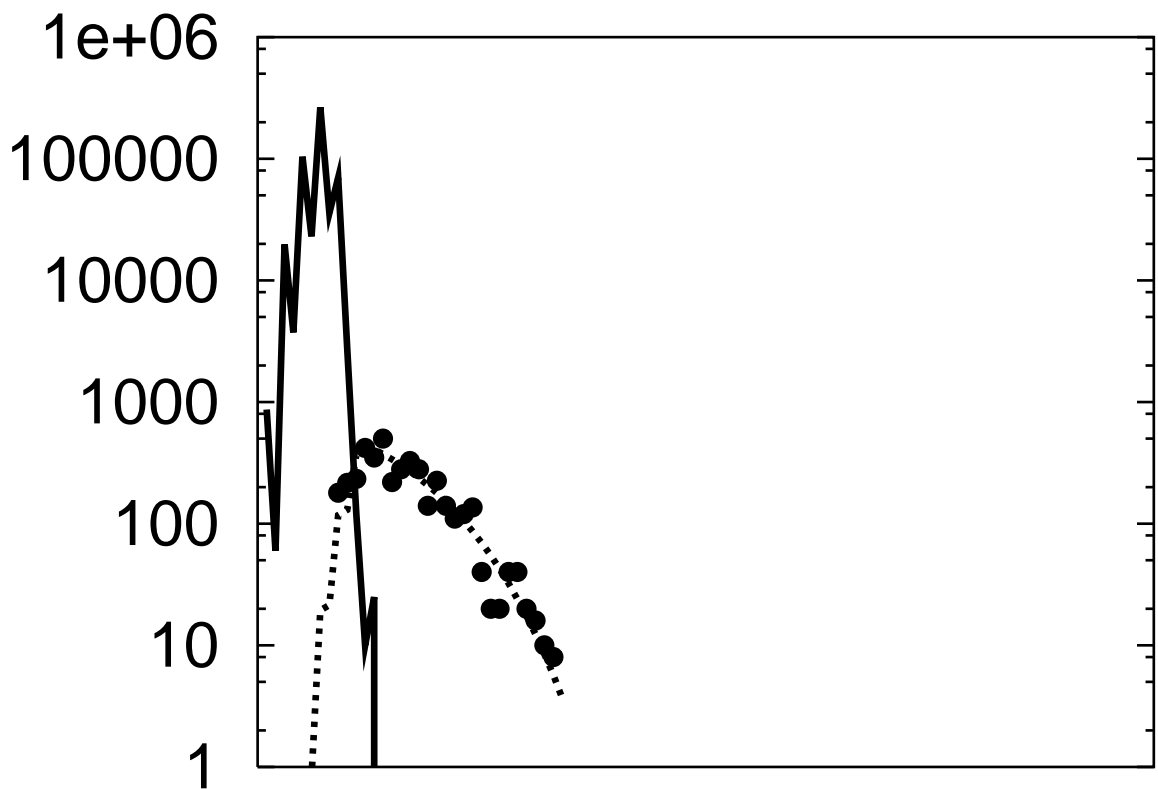
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



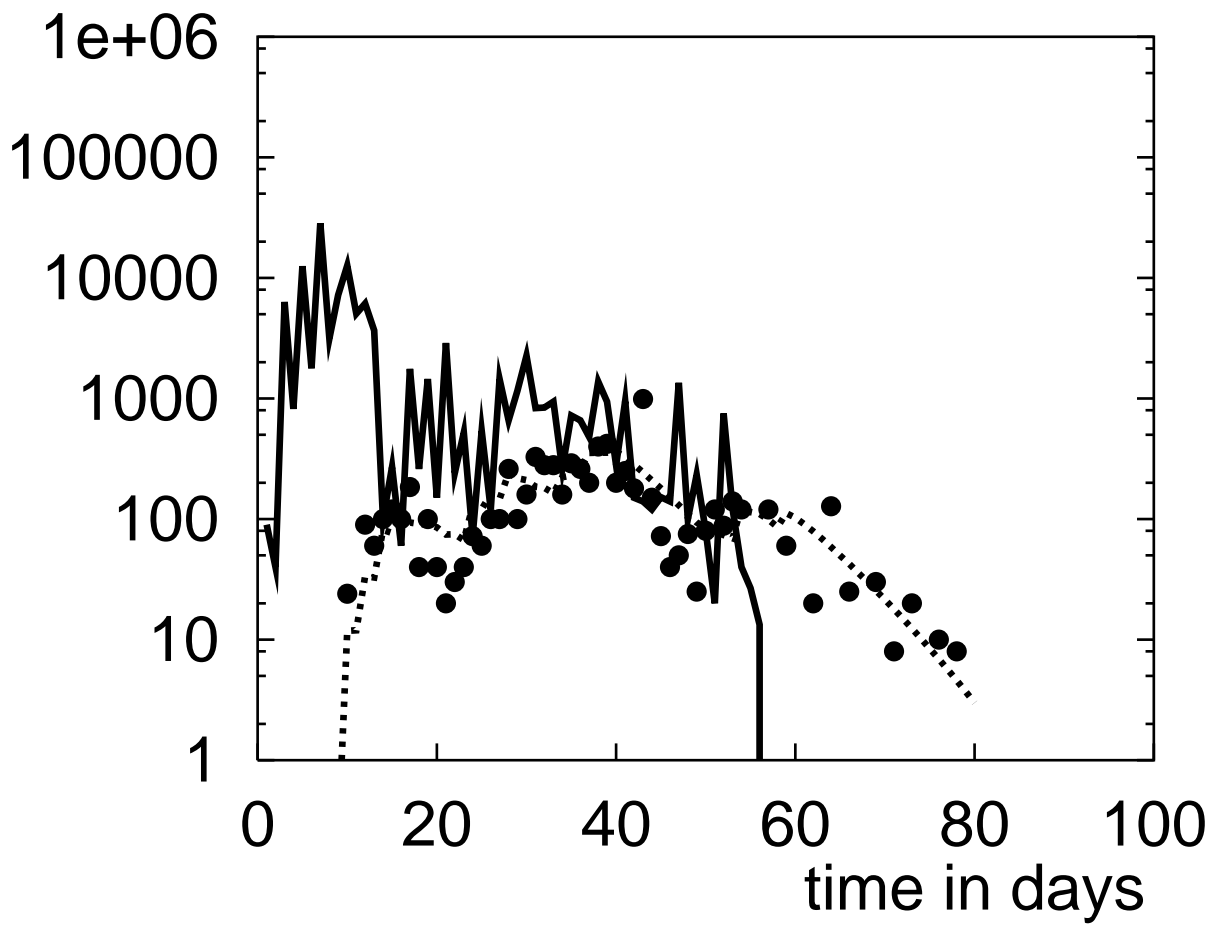
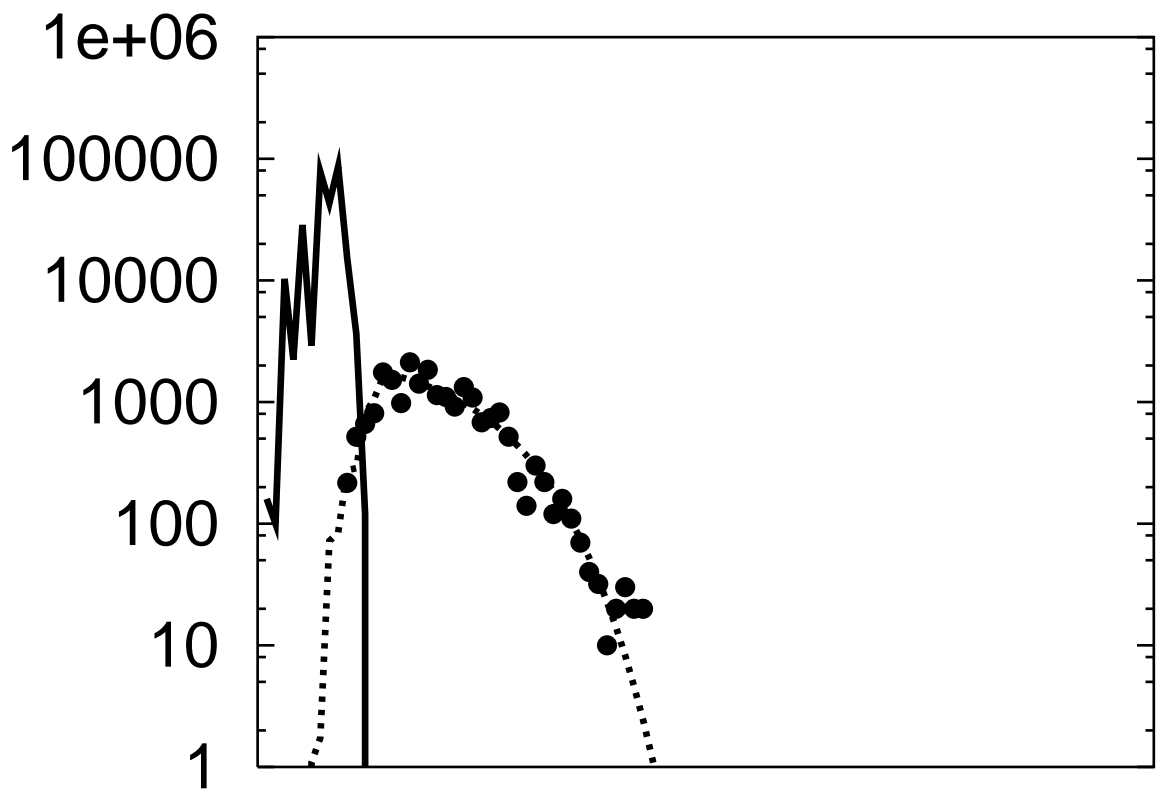
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



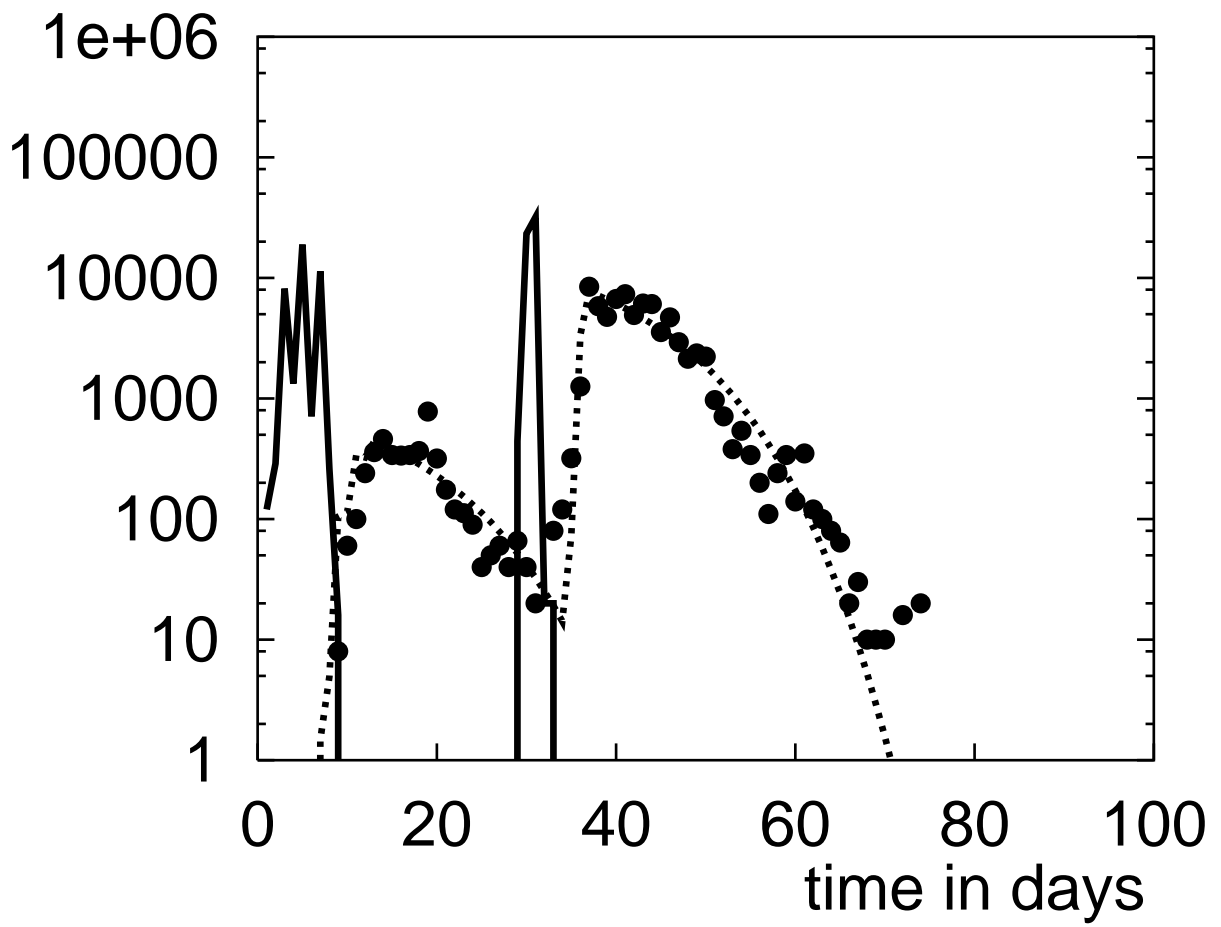
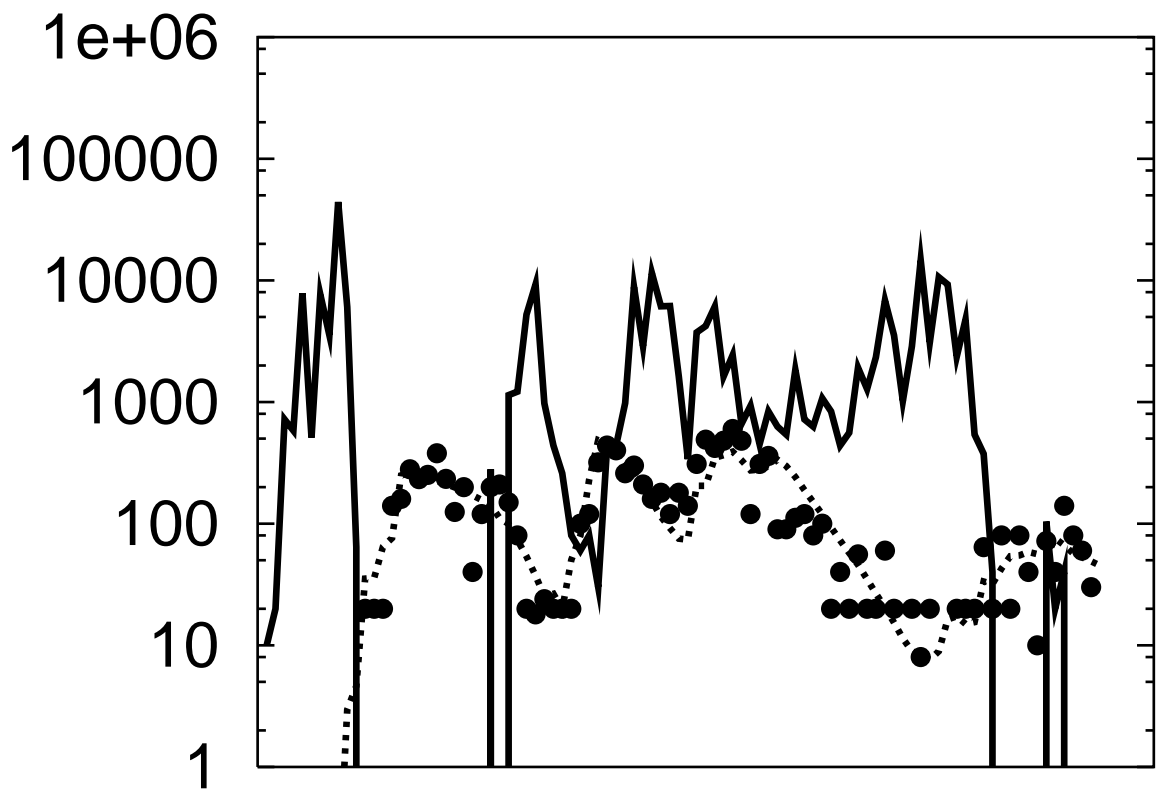
asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



asex. parasites ———
observ. gameto. •
expect gameto. ·····

parasites per μl blood



asex. parasites ———
observ. gameto. •
expect gameto. ·····