

Report

Quantification of blood intake of the head louse: *Pediculus humanus capitis*

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Abstract

Although head lice, *Pediculus humanus capitis*, are globally prevalent blood-sucking ectoparasites, the amount of blood imbibed by head lice has not been determined. This study investigated this parameter, as regular loss of a small quantity of blood may lead to an iron deficiency and anaemia. Adult female lice (66), adult males (46), and nymphs (152) were weighed before and after feeding in groups of 17–109 lice. The average amounts of blood imbibed at a single feed were: adult female louse (0.0001579 ml), adult male (0.0000657 ml) and nymph (0.0000387 ml). Assuming three feeds per day by an average infection of 30 lice (10 females, 10 males, and 10 nymphs), the average child with active pediculosis would lose 0.008 ml of blood per day. This amount of blood loss is of no clinical significance even in iron-deficient children. The most heavily infected child observed with 2657 lice could be expected to lose 0.7 ml/day or 20.8 ml/month, which may be of clinical importance in a child on an adequate diet, and would be significant in an iron-deficient child. However, if head lice feed more often than three times a day, a heavy infestation would have a greater potential to lead to iron deficiency. The frequency of feeding of head lice on the head of the human host needs to be determined.

Introduction

Head lice, *Pediculus humanus capitis*, rely solely on human blood for growth and survival.¹ Blood is sucked from scalp capillaries of the host through a feeding tube extruded from the louse's head. This has not been described for head lice, but for body lice (*Pediculus humanus corporis*) the feeding apparatus consists of a structure formed of three bilaterally paired stylets,² which is not visible in the nonfeeding louse (Fig. 1a). At the front of the head forming the borders of the mouth is the haustellum, a small tube-like structure with a gap ventrally (Fig. 1b). The haustellum is armed with bilateral hooks medial to its lateral walls (Fig. 1c). Prior to feeding, these hooks evert and attach the head of the louse to the skin.² The stylets then cut the skin and are inserted into a capillary. Saliva is delivered to the site and blood is imbibed. While the louse is feeding, the cibarial pump in the pharynx rhythmically fills and empties several times per second and blood is sucked into the alimentary tract.² Blood flows rapidly into the midgut and in most instances, when fully fed, the louse defecates while feeding. Feces usually appear as dark red, dry pellets, which frequently adhere to one another in a string.² Feces are usually from the previous meal, but in lice that feed for greater than 10 min, the blood from the current meal may start to be defecated (Rick Speare 1999 personal observation).²

Most lice cease feeding within 4–15 min. Head lice are said to feed 3–5 times a day,^{3,3} but this appears to be an estimate only and is not based on any observational data on the head of human hosts.

Head lice appear to be well adapted to the human host, and have been parasitic on humans for at least 9000 years.⁴ The impact of head lice on human health has been poorly investigated,⁵ and although it seems minor, a more detailed study is warranted owing to the high prevalence of pediculosis in children.^{6,7} Pediculosis is usually a chronic infection lasting at least 1 month, resulting in a continuous blood loss as lice feed, and this could theoretically lead to an iron deficiency and anaemia. However, the literature contains no data on how much blood a head louse imbibes. Hence, this study was conducted to measure how much blood head lice take when they feed and to calculate whether in theory this could be of clinical significance.

Methods

Lice

Pediculus humanus capitis from naturally infected primary school children participating in regular school head lice control programs in Townsville, Australia, were collected from dry hair by use of a fine tooth comb with cylindrical teeth. Female and male adult lice

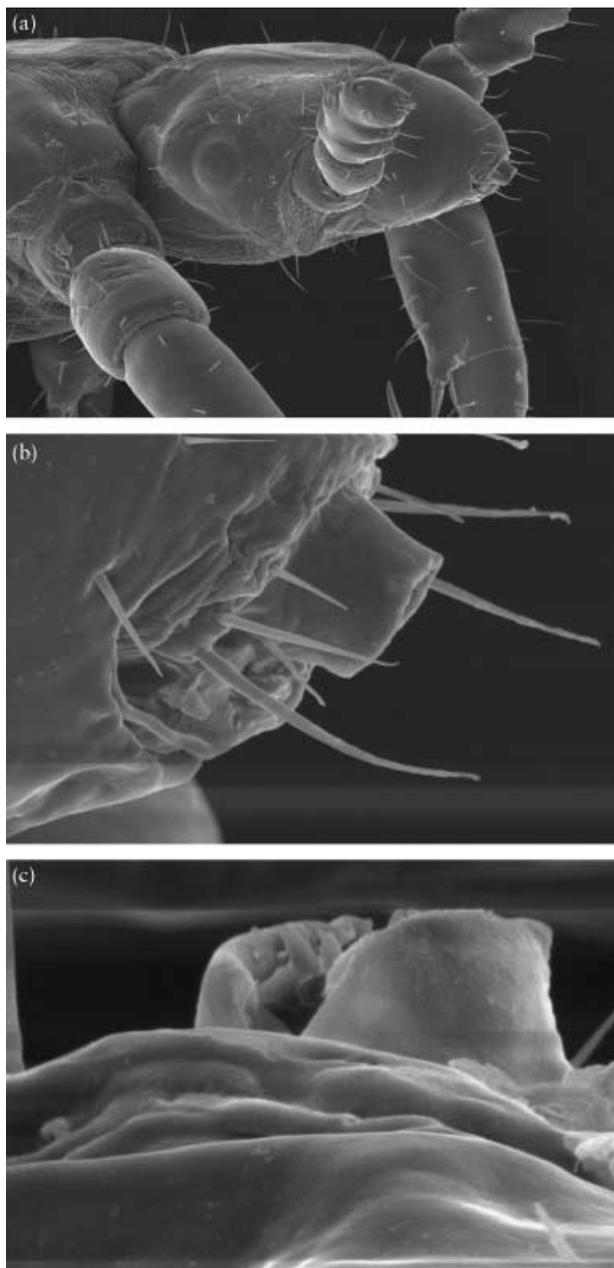


Figure 1 Head of a head louse (*Pediculus humanus* var. *capitis*; scanning electron micrograph). (a) Oblique view of the head. Haustellum is the tube-like structure at the front of the head. (b) Lateral view of the “mouth” of a head louse showing the tube-like haustellum from which the stylets are extruded. (c) Haustellum (ventro-oblique view) showing the ventral gap and one set of hooks medial to the lateral wall of the haustellum. These hooks are everted and attached to the skin prior to the stylets being inserted into the skin

and nymphs were placed on cut strands of human hair in plastic Petri dishes, and held at 25–29 °C (77–84 °F) for 6–8 h in an atmosphere with a relative humidity of approximately 65–80%. Prior to feeding, lice were selected after a thorough examination under a dissecting microscope. Lice were rejected if they were (1) injured, (2) inactive, or (3) their abdomen showed any degree of collapse indicating dehydration. Of the remainder, only lice whose midgut was largely devoid of blood were selected. These lice were sorted into groups composed of one of three life stages, adult females, adult males or nymphs, with the latter including first, second and third stage instars. Descriptions of body lice were used to determine these stages.²

Blood feeding

Each group was weighed on an electronic balance (Mettler AE200, Port Melbourne, Victoria, Australia) accurate to 0.0000 g, allowed to feed for 15 min on the dorsum of a hand, and then reweighed. After 15 min the majority of head lice ceased feeding. The difference in group weight was taken as the amount of blood imbibed. After feeding, each louse was examined under a dissecting microscope to confirm the presence of fresh blood in its intestine. The amount of blood imbibed was calculated using the formula:

$$Bi = \frac{\sum LW_{post} - \sum LW_{pre}}{N - Nnf}$$

where, in a particular group, Bi (weight of ingested blood) equals the sum weight of all lice after feeding ($\sum LW_{post}$) minus the sum weight of all lice before feeding ($\sum LW_{pre}$) divided by the total number of lice (N) minus the number of lice in the group that were observed not to have fed (Nnf), as the latter did not contribute to the total amount of blood taken. The technique of weighing groups of sucking lice to estimate the amount of blood ingested has precedence in experimental work on body lice.⁸ The volume of blood imbibed was calculated by using a specific gravity of blood of 1.058 for the male donor⁹ and dividing the weight of blood ingested by 1.058.

Results

A total of 264 lice fed successfully; 66 adult females, 46 adult males, and 152 nymphs tested in eight groups (Table 1). Adult female lice imbibed an average of 0.1670 mg of blood, 2.4-fold the amount of blood imbibed by males (0.0695 mg), and 4.1-fold the amount of blood imbibed by nymphs (0.040929 mg). When converted to volume, the average volume of blood imbibed by a female, male and nymphal louse was 0.0001579 ml, 0.0000657 ml, and 0.0000387 ml, respectively. The average body weight of an unfed adult female louse, adult male louse and nymph was 0.705 mg, 0.373 mg and 0.207 mg, respectively. The average weight of blood imbibed per body weight of louse was higher for females than males and nymphs; 0.2571 mg blood/mg body wt, 0.1892 mg blood/mg body wt and 0.1979 mg blood/mg body wt, respectively.

Table 1 Weights and amount of blood imbibed by head lice in a single feed on the dorsum of a hand 6–8 h after removal from the head

Group number	Stage	No. of lice	Wt of group of lice (mg)	Mean wt of louse (mg)	Wt of blood imbibed by group of lice (mg)	Number of lice feeding	Mean blood imbibed per louse (mg)	Blood imbibed per body weight of louse (mg/mg)
1	Adult female	20	14.3	0.715	3.5	20	0.175	0.2448
3	Adult female	17	11.8	0.694	3.2	17	0.188	0.2712
7	Adult female	30	16.2	0.540	4.0	29	0.138	0.2554
Total	Adult female	67		0.704559 ± 0.09558		66	0.167055 ± 0.026076	0.25713 ± 0.013297
4	Adult male	29	11.2	0.386	1.3	29	0.045	0.1161
8	Adult male	17	6.1	0.359	1.6	17	0.094	0.2623
Total	Adult male	46		0.372515 ± 0.019363		46	0.069473 ± 0.03485	0.1891836 ± 0.103396
5	Nymph	30	6.1	0.203	1.0	25	0.042	0.2049
6	Nymph	30	6.3	0.210	0.8	20	0.040	0.1905
9	Nymph	109	22.6	0.207	4.4	107	0.041	0.1983
Total	Nymph	169		0.206891 ± 0.003356		152	0.040929 ± 0.00085	0.197908 ± 0.00723

In "Total" the figure is given as average \pm standard deviation.
Wt = weight.

Discussion

Two factors are required to estimate the amount of blood removed in any case of pediculosis once the number of lice is known: (1) the volume of blood imbibed per louse at a particular life stage, and (2) the number of times a head louse feeds per day. Unfortunately, hard data on the number of times a day each stage feeds are not available. If we assume that head lice feed three times per day, the daily amount of blood imbibed by an adult female, adult male, and nymph is 0.00047, 0.00020 and 0.00012 ml, respectively.

A calculation can be made to determine population level risk by using the average number of lice found in a typical infested case. In a previous study,¹⁰ children in north Queensland state primary schools were shown to harbour an average of 30 head lice per head (median: 6). Other studies show widely ranging averages,⁷ but 30 is a reasonable figure to use for a population with a prevalence greater than 10%. The maximum number of head lice found on a single head in the above-mentioned study¹⁰ was 1623, but subsequently a child was found with 2657 lice (Rick Speare, personal observation 2001), which may be the greatest number of lice ever found on a single head. Using the figures found in this study and assuming three feeds per day by 30 lice (10 females, 10 males, and 10 nymphs), the average child with active pediculosis would lose 0.008 ml per day or 2.1 ml per year. If lice are assumed to feed many more times, the figures still indicate minimal blood loss. Even at 10 feeds per day, the average amount of blood lost per day and month is 0.03 and 0.79 ml, respectively. This amount of blood loss is of no clinical significance even in iron-deficient children.

At birth, normal infants have approximately 75 mg of iron per kilogram of body weight.¹¹ Dietary iron is not required for 2–3 months owing to iron stores present at birth, but from 4 to 12 months infants require 0.96 mg/day of dietary iron.¹² By 1 year, a child will have tripled its body weight and doubled its iron stores. From 1 to 5 years, a child will require 0.6–0.7 mg/day rising to 1.17 mg/day in 6–11 years olds and 1.8–2.0 mg/day in 12–16 years olds. Iron is not excreted in urine or feces, but is lost with cells from the skin and interior body surfaces (intestines, urinary tract and airways). This loss is estimated at 14 μ g/kg of body weight/day,¹³ equivalent to 1 mg/day in an adult and 0.6 mg/day in an average primary school child. Thus, on average, primary school children require approximately 1.5 mg/day and lose 0.6 mg/day, leaving 0.9 mg/day for other body functions. Removal of 1 mg/day of iron (2 ml/day or 60 ml/month of blood) by lice could unbalance this situation leading to iron deficiency and subsequent anaemia. In adult females it is accepted that regular menses in excess of a measured menstrual blood loss of 80 ml of bleed each month will inevitably lead to anaemia.¹⁴

If blood loss in the average infection is insignificant, could blood lost to lice in the rare heavily infected child cause iron deficiency? If we use the example of the child with 2657 lice as an extreme case and assume that a conservative three feeds are taken per day by an equal number of females, males, and nymphs, we can calculate that the lice would remove 0.7 ml of blood per day or 20.8 ml/month. For children on an adequate diet, loss of this amount of blood may be of clinical significance. For the child with a very heavy infection plus iron deficiency, blood loss owing to head lice may play a contributory role in iron deficiency.

In the heavily infected case, an assumption of a higher louse feeding rate of 10 feeds per day gives blood losses of 2.3 ml per day or 69.6 ml per month. In a child, this level of blood loss would cause anaemia leading to the many well-described effects of iron deficiency. Further studies are required to clearly determine the number of times a louse feeds per day so that this matter can be finalized.

The results also provide some insight into head louse physiology. The amount of blood imbibed was greater per unit of body weight for adult female lice than for adult males or nymphs, possibly owing to the greater metabolic and nutritional demands of producing eggs. Interestingly, nymphs also had a greater blood intake per body weight than males, probably reflecting the demands of growth and moulting.

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