HEAD LICE

Ian Burgess from the Medical Entomology Centre in Cambridge, UK[1], writes about the detection and treatment of these pests, which he describes as the "Number One Enemy of the People"

Introduction

Head lice are fairly benign, as ectoparasites. They cause no particular pathology on their hosts, they are not vectors of disease and, provided basic elements of hygiene are maintained, there is relatively little risk of secondary infections invading any lesions resulting from bite reactions in the skin. Most societies have at one time or another learned either to live with lice or else to manage the infections in such a way that they caused neither excessive discomfort nor embarrassment to those with them. They have never been respecters of persons and, in past ages, various courtly guides to etiquette have described discreet ways to scratch the itch and probe for errant parasites in ways that do not cause distress to others.

In modern developed societies head lice have acquired a new status, that of Number One enemy of the people. Surveys have shown that this infection ranks of higher concern with parents than virtually all childhood ailments apart from meningitis! How can this be achieved by a secretive, slow breeding, vulnerable, and virtually harmless little insect? The simple answer is, firstly, the power of the press and, secondly, that most modern people are to some extent entomophobic, a characteristic that is greatly exacerbated if the insects happen to crawl on them or their children.

As with all members of the Anoplura (the sucking lice), head lice, *Pediculus capitis*, are obligate parasites of their host. They can be distinguished from their cousins the clothing (body) lice by their relatively smaller size and the greater level of indentation between abdominal segments. The controversy over whether these are two true species or sub-species has continued for decades. In practice it matters little. Head lice are found on the head alone and, although they undoubtedly gave rise to clothing lice sometime within the past 50,000 years, they rarely meet to interbreed.

In comparative terms, head lice are more vulnerable than most other anopluran lice because they need to take several blood meals daily. This permits them to lay between three and six eggs per day but also makes them susceptible to dehydration if prevented from feeding. Head lice removed from their host usually become sufficiently dehydrated that they cannot feed following about 8–10 hours of isolation under warm conditions.

In most western societies head lice are associated with school children and, as a result, schools have been targeted in attempts to eliminate the infection from society. The actual epidemiology of lice shows that lice are found most frequently on children of school age but are nothing to do with schools, as demonstrated in those societies where schools are not available to the majority. These institutions are merely places where those most at risk congregate. The probability of transmission in classrooms is quite limited by the relatively restricted number of opportunities for contact between children, even in modern relaxed classroom settings. During play, however, children are considerably

[1] Medical Entomology Centre, Cambridge Road, Fulbourn, Cambridge, CB1 5EL, UK

Stage in head louse development. Left to right: empty egg case (nit); nymph; adults on skin (illustrates difficulty in seeing and identifying them. Photos courtesy of BLM Health.

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more likely to engage in the level of physical contact that permits transfer of lice. Infection of adults and younger siblings does occur but primarily as a result of physical contact with those in the highest risk age group of around 7–12 years.

Biology and life cycle

Head lice are obligate blood feeders, which means that they require several meals of human blood each day to grow, develop and lay eggs. They need to feed every few hours and deprived of their hosts become non-viable in less than 24 hours through dehydration. They are only found on the scalp where they remain close to the skin, except when stimulated to move to another host.

Head lice are quite small; the length of adults has often been compared with that of a sesame seed, around 2.5–3.5 mm long and the immature lice are even smaller. They range from nearly colourless through to black, depending upon the amount of pigment deposited in the cuticle, but the majority of lice are semi-transparent over most of the body with small patches of pigment on the sides of the thorax and abdomen. In these insects the partially digested blood in the gut can be seen through the cuticle and this can make them difficult to see against either skin or amongst tresses of hair. The head louse moves only by crawling and for the majority of the time remains immobile, especially when disturbed. However, when lice are in the right physiological state for migration to a new host, mostly third instar nymphs and young adults, they can move rapidly over the short distance from the scalp to the surface of the hair.

An adult female head louse can lay 3–6 eggs per day and, although the life span has been shown to extend to around 30 days in the laboratory, most lice are lost through natural attrition due to grooming, shampooing and scratching long before this. At scalp temperature, eggs hatch in 7 days after being laid. Immature lice (nymphs) pass through three juvenile stages (instars) before becoming adults, which takes approximately 10 days. There is quite a high mortality during development so infestation builds up slowly. It has been observed that starting from a low level of infestation, for example one pregnant adult female, it takes approximately 4–6 weeks for an infection to become noticeable by relatively cursory examination (Burgess, 1991). A child that has a significant infection has usually been infested for several months.

Louse eggs are nearly transparent when they are first laid and remain pale throughout development of the embryo. They only turn brownish if the embryo dies and dehydrates. The female louse glues each egg to a hair strand a few millimetres from the scalp, where it is warm and humid. After hatching the empty eggshell (now called a 'nit') remains on the hair and appears white due to refraction of light at the internal surface of the shell. The glue that holds them in place binds the eggshells firmly so it cannot be as easily removed as dandruff and other hair debris. Some products claim to remove nits but the hair is more readily dissolved than the glue and in most cases the products merely lubricate the hair and allow the nits to slide more readily once dislodged by physical force.

Prevalence

Head lice have spread to all human communities and distribution is limited only by the level of detection, efficiency of treatment, and isolation of the individual from contact with its peer group. Generally, the more gregarious an individual is the greater the risk of infection but equally the greater the chances that they can pass on their lice. As a result the members of a community of most epidemiological significance tend to have lower parasite burdens whereas those with a heavy infestation are more isolated and unable to pass on their lice to others. In most human societies the level of infestation has traditionally been controlled by physical removal of lice by hand. This has the effect of improving the condition of the individual but without reducing the prevalence of infection. Nevertheless, for most people the treatments were incomplete and remaining insects continued the infection but at a lower level. This was demonstrated by a series of surveys conducted by Buxton, in which whole head shavings were collected and the lice counted. Although a few individuals were found with hundreds of lice the majority of those infected had less than 20 insects of all developmental stages with an overall mean of around 10 lice (Buxton, 1947). The low mean infection level found in those communities without recourse to insecticide treatment contrasts starkly with levels found on some children in our society today.

Quite how common head lice are is an unknown factor. Despite nurses visiting schools regularly in most developed countries between the 1940s and 1980s, and even currently in the USA, what data have been produced are not informative and do nothing to tell us what is the situation today. The need for an evaluation of prevalence and incidence of head louse infestation in developed countries is greater now than in the past. An up to date survey would go some way towards providing those responsible for management strategies with the information necessary for development of the right resources for assisting the public in dealing with the problem.

Detection

Fundamental to management of head louse infections is the ability to detect the presence of lice at an early stage. Traditional methods, in which the hair is parted and lice observed *in situ*, are not efficient. Public health workers worldwide have employed this methodology for decades and its lack of sensitivity partly accounts for the consummate failure of louse control efforts in the school environment. Diagnosis of low grade infections can only be made using detection combing techniques, which employ combs designed to lift out the smallest first instar nymphs as well as larger development stages. The best materials available at the moment are plastic combs that have parallel sided teeth no more than 0.3 millimetres apart. Whether used on wet or dry hair, combs of this type can identify the majority of infections at the first attempt. Routine use of the combs approximately weekly can identify infections before they have time to establish and so render the treatment process simpler and more effective.

Treatment

Treatment of head louse infection until the middle of the 20th century was universally based on mechanical removal of lice and eggs. Unfortunately many people were unsuccessful in dealing with the latter because the empty shells attached to hairs persist for months after hatching. These so-called nits have misled many people into thinking that an infestation was still active long after the death of all lice, mainly because they were unaware that the objects were empty egg shells or that they were not an indicator of continuing infestation. Consequently, the majority of data collected by the Schools Health Services in the UK between 1957 and 1987 were probably effectively useless because a high proportion of nurses involved in inspections had never seen live lice and had depended upon the presence of nits to make a diagnosis (BLM, 1984). As a result, many of the reported cases of "persistent offenders" against Section 54 of the Education Act 1944, which dealt with "verminous infestations" of school children, were merely children whose carers had not combed out the multitude of empty egg shells remaining from past infections.

When preparations containing synthetic insecticides were first introduced for control of head lice in the 1940s they were universally greeted with enthusiasm because the laborious and uncomfortable task of combing out lice and eggs was not required. Even now, despite the concern of many people regarding the personal and environmental toxicity of conventional neuroactive insecticides, the majority of people in most developed countries are prepared to use these products for the convenience and the likelihood that they will be successful to cure the infection, if applied properly.

For most of the past 60 years application of insecticide based treatments has been the most effective way of dealing with head louse infections (Table 1). Unfortunately many of the products released for consumer use have been less than wholly effective under the conditions of use, either because they were inadequately tested for efficacy before marketing or because when used by consumers the instructions were not adhered to. Almost universally the shampoo preparation was employed, presumably related to the connotations of dirtiness fallaciously associated with head louse infection (Maunder, 1983). As a vehicle for insecticide delivery these preparations were mostly doomed to failure and it was actually remarkable that they not only persisted for so long but also that resistance to the insecticide components did not develop more rapidly. Almost certainly the latter problem did not arise because the insects were subjected to so little selection pressure that no specific tolerance mechanisms were required to deal with the minimal concentrations of insecticide coming into contact with the lice, if any was absorbed at all (Burgess, 1996). Few countries employed evaporating lotions as vehicles but this type of preparation became the norm in the UK from the 1970s onwards. Unfortunately, despite the relative effectiveness of such preparations if used correctly, misuse and poor formulation ultimately acted to exacerbate the risk of selection for resistance mechanisms (Burgess, 1990, 1991; Burgess *et al.*, 1992).

Table 1. Pesticides licensed for use in the UK for treatment and control of head louse infestation.

Active ingredient	Chemical class	Brand names
malathion	organophosphate	Suleo-M, Derbac-M, Prioderm, Quellada-M
permethrin	pyrethroid	Lyclear
phenothrin	pyrethroid	Full Marks
carbaryl (carbaril)	carbamate	Carylderm

NB. As with all medicines, these preparations are toxic to some extent and care should thus be exercised in their use, with particular care being taken to avoid accidental ingestion or contact with eyes. Alcohol based lotions, especially those containing monoterpenes, may trigger respiratory stress in susceptible individuals and for these an alternative water based preparation may be more appropriate. There is no controlled evidence that electronic combs or any other form of alternative therapy is effective. Currently no product that does not contain a conventional pesticide has been licensed for this application in the UK.

Insecticide resistance

The relative rapidity of development of insecticide resistance by head lice; the failure of various authorities to deal with the problem; the inability of individual practitioners to recognise the problems with which they were confronted; should be an object lesson to all in how not to manage an insect problem. Of course, management of head louse infestation in the community does have one major disadvantage when compared with other pest insect management. In some instances a farmer may be successful in protecting his crop by reducing the pest population by just 30–40% and a similar reduction in mosquitoes may interrupt transmission of a vector-borne disease. Even in domestic pest control and animal husbandry, reduction of the pests by only 50–80% frequently heralds success. In dealing with head lice nothing less than total elimination is acceptable to the consumer, even if it is not always required biologically. The result has been that most populations of head lice have been subjected to the highest level of selection pressure for development of insecticide resistance, especially resulting from the near universal use of permethrin and other pyrethroids.

Resistance to permethrin has now been identified in France (Chosidow *et al.* 1994), the Czech Republic (Rupes *et al.*, 1995), Israel (Mumcuoglu *et al.*, 1995), the UK (Burgess *et al.*, 1995; Downs *et al.*, 1999), Argentina (Picollo *et al.,* 1998), and the USA (Pollack *et al.,* 1999; Lee *et al.,* 2000). Resistance to malathion has also been identified in the UK (Burgess and Brown 1999; Downs *et al.*, 1999). These problems have had two results. The first has been an unwarranted increase in the use of insecticide products that has almost certainly exacerbated any low grade resistance present in the lice as a consequence of additional selection pressure. The second has been the blossoming of a plethora of alternative methodologies and unlicensed products for dealing with head louse infection. Top of the list in the former category has been physical

removal of lice by combing, the best known version of which is "Bug Busting", which aims to eliminate lice by combing hair soaked with conditioner four times over a two week period. The rationale behind this approach is that all lice can be removed on the first occasion so that subsequent combing sessions only need to remove newly hatched nymphal lice. This is fine theoretically but does depend somewhat heavily on success at the first attempt. In most cases people continue to comb for more than the recommended period, and in some cases are never successful because they simply do not grasp what they are doing or why. Two recent studies have shown that combing is partially successful, more so when compared with a failing product, like permethrin creme rinse applied once, (Bingham *et al.*, 2000), but less so when compared with a robust product, like alcoholic malathion lotion applied twice (Roberts *et al.*, 2000).

Management of head lice for both the individual and the community is obviously more difficult now that the insects have acquired resistance but the real problems arise from bad practice. For some time, some groups of health care workers have struggled to avoid confronting this issue because they have felt that it is someone else's problem and responsibility. Although the responsibility for management and prevention in the family has always legally resided with parents and guardians they cannot manage without accurate professional help and guidance. Worryingly, many primary health care workers are still unfamiliar with the differences between insecticides and are sometimes unclear even about which active ingredients are found in named proprietary brands.

Current best practice

Current best practice is based on simple logical procedures that should be employed in dealing with any infective organism. The great advantage of dealing with this one is that there are no reservoirs of insects that cannot be traced or eliminated with reasonable care. Consequently, even in a climate of moderate resistance management is possible if the simple guidelines are followed.

- Diagnosis is the first key issue. Judicious application of detection combing is the only means for identification of active infections and only after a living louse has been found should treatment be initiated.
- Regardless of the type of treatment (chemical or mechanical) it should be performed thoroughly. In the case of chemical agents, all products except mousse and crème rinse products should be applied for a minimum of 8 hours on two occasions a week apart, the second being to kill nymphs emerging from eggs that survive a single application. Mousse and crème rinse treatments should be applied no less thoroughly, but have a shorter application time, and a repeat application is possibly more important for these preparations. Mechanical treatments require a higher level of commitment because they are time consuming and it is unreasonable to expect to be able to thoroughly comb through shoulder length hair in less than 30 minutes. Some people have reported taking two hours or more for each combing session. With combing, if an adult louse is found at any time after the first combing session the treatment period must be extended by at least one additional week to accommodate the period required for hatching of any eggs laid by those lice.
- During the week after the completion of treatment, detection combing should be performed to ensure that the treatment process has been effective. If it has not, an alternative method or alternate chemical entity should be used as resistance might be the cause. This is the basis of the mosaic process of treatment use, which has been remarkably difficult to communicate in some quarters.
- Ideally, all close contacts of an infected individual should be checked for infection and treated if appropriate. For this the concept of contact tracing was encouraged as long ago as the mid-1980s but most people are either reluctant to do it for social reasons or do not understand the concepts involved. Consequently, raising the awareness of the importance of checking children for lice on a regular basis can be an important component of reducing transmission through the community by not allowing infections to become established.

Plastic combs for head lice detection and removal. Photo courtesy of BLM Health

In places, where these simple procedures have been employed consistently, lice continue to cause infections but they have become more manageable (Burgess and Brown, 1999). Instrumental in this has been the recent development in some areas of pharmacist prescribing of head louse treatments. The popularity of this initiative with the public and professionals has indicated that this may be a more appropriate path for effective management of the infestation in the future. The challenge now is to extend the success experienced by the most efficient practitioners to others of their colleagues who have hitherto found head lice to be something of a nightmare.

References

Bingham, P.; Kirk, S.; Hill, N.; Figueroa, J. (2000) The methodology and operation of a pilot randomized control trial

of the effectiveness of the Bug Busting method against a single application insecticide product for head louse treatment. *Public Health* **114**, 265–268.
BLM (1994) The Diagnostic Pocket Pack. BLM Health, Cambridge, 12pp.
Burgess, I. (1990) Carbaryl lotions for head lice – new laboratory tests show variations in efficacy. *Pharmaceutical Journal* **245**, 159–161.
Burgess, I. (1991) Malathion lotions for head lice – a less reliable treatment than commonly believed. *Pharmaceutical Journal* **247**, 630–632.
Burgess, I. F. (1996) Shampoos for head lice treatment – comparative *in vitro* tests. *Pharmaceutical Journal* **257**, 188–190.
Burgess, I. F.; Brown, C. M. (1999) Management of insecticide resistance in head lice *Pediculus capitis* (Anoplura: Pediculidae). *Proceedings of the 3rd International Conference on Urban Pests*, Prague, 1999, 249–253.
Burgess, I.; Veal, L.; Sindle, T. (1992) The efficacy of d-phenothrin and permethrin formulations against head lice: a comparison. *Pharmaceutical Journal* **249**, 692–693.
Burgess, I. F.; Brown, C. M.; Peock, S.; Kaufman, J. (1995) Head lice resistant to pyrethroid insecticides in Britain. *British Medical Journal* **311**, 752.
Buxton, P.A (1947) *The Louse*. 2nd Edition, Edward Arnold, London, 115pp.
Chosidow, O.; Chastang, C.; Brue, C.; Bouvet, E.; Izri, M.; Monteny, N.; Bastuji-Garin, S.; Rousset, J.-J.; Revuz, J. Controlled study of malathion and *d*-phenothrin lotions for *Pediculus humanus* var *capitis*-infested schoolchildren. *Lancet* **344**, 1724–1727.
Downs, A. M. R.; Stafford, K. A.; Harvey, I.; Coles, G. C. (1999) Evidence for double resistance to permethrin and malathion in head lice. *British Journal of Dermatology* **141**, 508–511.
Lee, S. H.; Yoon. K.-S.; Williamson, M. S.; Goodson, S. J.; Takano-Lee, M.; Edman, J. D.; Devonshire, A. L.; Clark, J. M. (2000) Molecular analysis of kdr-like resistance in permethrin-resistant strains of head lice, *Pediculus capitis*. *Pesticide Biochemistry and Physiology* **66**, 130–143.
Maunder, J. W. (1983) The appreciation of lice. *Proceedings of the Royal Institution of Great Britain* **55**,1–31.
Mumcuoglu, K. Y.; Hemingway, J.; Miller, J.; Ioffe-Uspensky, I.; Klaus, S.; Ben-Ishai, F.; Galun, R. (1995) Permethrin resistance in the head louse *Pediculus capitis* from Israel. *Medical and Veterinary Entomology* **9**, 427–432.
Picollo, M. I.; Vassena, C.V.; Casadio, A. A.; Massimo, J.; Zerba, E. N. (1998) Laboratory studies of susceptibility and resistance in *Pediculus capitis* (Anoplura: Pediculidae). *Journal of the Entomological Society of America* **35**, 814–818.
Pollack, R. J.; Kiszewski, A.; Armstrong, P.; Hahn, C.; Wolfe, N.; Rahman, H. A.; Laserson, K.; Telford, S. R. III; Spielman, A. (1999) Differential permethrin susceptibility of head lice samples in the United States and Borneo. *Archives of Pediatrics and Adolescent Medicine* **153**, 969–973.
Roberts, R. J.; Casey, D.; Morgan, D. A.; Petrovic, M. (2000) Comparison of wet combing with malathion for treatment of head lice in the UK: a pragmatic randomised controlled trial. *Lancet* **356**, 540–544.
Rupes, V.; Moravec, J.; Chmela, J.; Ledvinka, J.; Zelenkova, J. (1995) A resistance of head lice *Pediculus capitis*) to permethrin in Czech Republic. *Central European Journal of Public Health* **1**, 30–32.

Websites

http://www.fam-english.demon.co.uk/phmeghl.htm#Chemical%20treatment
http://www.pediculosis.com
http://www.hsph.harvard.edu/headlice.html

Ian F Burgess first became interested in ectoparasites whilst studying medical parasitology at the London School of Hygiene and Tropical Medicine in 1972. Several posts and 11 years later he joined the newly formed Medical Entomology Centre in Cambridge, UK, where in 1988 he became director with responsibility for the administration of clinical and epidemiological studies in UK and abroad. During the past few years he has been particlarly interested in the activity of insecticide formulations and evaluation of the development of insecticide resistance in the community.

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