# The Vagina as an Ecosystem

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**Abstract**

Viewing the vagina as an ecosystem supports a naturopathic approach to addressing a variety of vaginal problems. Remove the cause, restore balance, do no harm, etc. are concepts that may well make more scientific sense than eradication of a single pathogen. This article presents the three elements of the vaginal "ecosystem" as vaginal epithelium, vaginal microflora and the interactions between them, and the beginnings of a discussion of clinical applications of this paradigm.

RESEARCH REVIEW

A review of the recent literature reveals a trend toward viewing the vagina as an ecological system. (1-5) An ecosystem is a complex interaction between a habitat and its biota. In the case of the vagina, the vaginal epithelium is the habitat and the colonizing flora are the biota. Understanding the vagina as an ecosystem which maintains homeostasis through a number of complex mechanisms, favors a naturopathic approach to a number of vaginal problems. In the vaginal ecosystem paradigm, ideas such as removing the cause, restoring balance, and using the least harmful treatment take precedence over the more conventional ideology of eradicating a single pathogen.

The vaginal flora are comprised of a wide variety of bacterial and fungal species with many complex physiochemical interactions taking place between the flora and the vaginal tissue as well as between the various biotic species. (1) The species composition and density can be altered by changes in the physical and chemical conditions of the vagina. Conversely, physical and chemical conditions can be altered by changes in the species composition and density. So there are three elements that make up the vaginal ecosystem: the vaginal epithelium, the vaginal microflora and the interactions between them that maintain a dynamic equilibrium.

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## Vaginal Epithelium

The vaginal epithelium is a cell renewal system driven by estrogen stimulation. It provides the conditions necessary to promote microbial colonization. The epithelium is affected by the microbes and also by external factors.

In order to support the growth of microbial flora, nutrients must be available in the vagina. The known vaginal secretion content includes 90-95% water, organic and inorganic salts, urea, carbohydrates, especially glycogen, mucins, fatty acids, albumins and immunoglobulins. (6) These come from a number of sources including sloughed epithelial cells, serous transudate, menstrual fluid, and endocervical gland secretions. (1)

Both the pH and the oxidation reduction potential of the vaginal environment influence the composition and density of the flora. The pH during a woman's reproductive period is 4-4.5, which favors acidophilic species such as Lactobacilli. The acidic environment is unfavorable for the growth of certain microbes, probably the result of the pH influencing the solubility of nutrients and/or enzyme system function. (1) The low pH is partly due to lactic acid production from the metabolism of glycogen by Lactobacilli, but fatty acids produced by the vaginal epithelial cells may be another important source. (6) The vagina has a low oxidation-reduction potential which favors anaerobic species such

as Lactobacillus, Bifidobacterium, etc. This may be the result of oxygen consuming species such as Streptococcus, Staphylococcus and E. coli depleting the environment of oxygen. (1)

Microflora require some method of adhering to the vaginal epithelium. Fibronectin is found in vaginal fluid. It is a glycoprotein with adhesive properties, and can provide a foundation for microbial flora to adhere to the mucosal surface. Low pH enhances the binding of Lactobacillus to fibronectin. (7) Lactobacilli also exhibit a high degree of adherence to the vaginal epithelium through their glycocalyces (exopolysaccharides). (8)

## Vaginal Microflora

The normal vaginal microflora are relatively stable, and during the reproductive period are dominated by Lactobacillus species. However, there is also a wide variety of anaerobic and aerobic species. Besides the dominant facultative Lactobacilli, the normal flora can include Staphylococcus, Ureaplasma, Corynebacterium, Streptococcus, Peptostreptococcus, Gardnerella vaginalis, Bacteroides, Mycoplasma hominus, Candida, Eubacterium, Bifidobacterium, Propionibacterium, Escherichia coli, Klebsiella pnuemoniae, Enterococcus, and Fusobacterium. (6) It has been observed that the composition of the microflora can differ in each anatomic region of the vagina. (6)

The initial colonization of the vagina takes place as the infant passes through the mother's vagina. Thus, the newborn girl is colonized with the same microbial strains as the mother. (3)

Estrogen stimulation probably plays an important role in the species composition of the vagina, evidenced by the difference in species at different ages. (6) At birth, female infants have high levels of transplacental maternal estrogen and also have abundant Lactobacilli. When the maternal estrogen is depleted the glycogen content of the epithelium drops, the pH rises to 7.0, the numbers of Lactobacilli drop and a mixed flora of gram positive cocci, gram positive bacilli and gram negative bacilli predominate until menarche. At menarche, the increased levels of estrogen once again promote Lactobacilli colonization through increased glycogen content and decreased pH. At menopause the environment gradually reverts to the premenarchal conditions and the Lactobacilli again decline. During pregnancy, with its high estrogen levels, the Lactobacilli become even more predominant. (6) Candida also flourishes with the higher estrogen levels, possibly due to estrogen receptors on the Candida. (2)

### Interactions

Interactions between the vaginal epithelium and the vaginal microflora, and between the various vaginal microflora serve to maintain a state of dynamic equilibrium.

Recent research indicates that the dominant Lactobacilli control the microflora, including themselves, through a combination of factors including production of lactic acid, hydrogen peroxide, bacteriocidins and inhibitory proteins. (2,3,6) In particular, studies demonstrate that hydrogen peroxide-producing Lactobacilli may be essential to maintaining the normal ecological balance. (9-13) Hydrogen peroxide-producing Lactobacilli have been shown to inhibit vaginal colonization with Bacteroides, Peptostreptococcus, Mobiluncus, Ureaplasma, Gardnerella, Trichomonas, Candida and Chlamydia. (10)

Synergistic interactions may be occurring. For example, the metabolic end product of one microorganism might serve as the growth substrate for a second species. Species interdependence has been demonstrated in the treatment of polymicrobial infections which respond to antibiotics to which some of the pathogenic microorganisms are not susceptible. (1)

### Disruption of Ecological Balance

If the normal ecological balance is disrupted, then symptomatic conditions can result. (4) One prevalent ecological imbalance is known as bacterial vaginosis. This is a condition in which the normally dominant Lactobacilli are replaced by other vaginal species such as Gardnerella or Mobiluncus. One study showed that 96% of healthy women are colonized with hydrogen peroxide-producing Lactobacilli, while only 6% of women with bacterial vaginosis have adequate vaginal colonization. (12) This has been confirmed by a number of other researchers. (11, 13) More specifically, one study demonstrated that hydrogen peroxide-producing Lactobacilli are toxic to both Gardnerella and Bacteroides, especially if combined with a peroxidase and a halide such as chloride (both present in the vagina). (11) In a study with pregnant women, those women colonized with hydrogen peroxide-producing Lactobacilli were less likely to have bacterial vaginosis. (10) It appears that a deficiency of hydrogen peroxide-producing Lactobacilli probably precedes bacterial vaginosis. One researcher has even suggested that bacterial vaginosis is a congenital disease, resulting when a woman is colonized at birth with the "ecologically wrong Lactobacilli." (3) Women colonized with hydrogen peroxide-producing lactobacilli are also less likely to have symptomatic candidiasis. (10)

Also significant is that hydrogen peroxide formed by lactic acid producing bacteria in the presence of peroxidase and a halide can kill viruses and tumor cells. (11) Klebanoff has shown that hydrogen peroxide-producing Lactobacilli in high concentration are viricidal to HIV-1. (14) His findings suggest that Lactobacilli may affect the heterosexual transmission of HIV. Women with few or absent hydrogen peroxide-producing Lactobacilli may be at greater risk of HIV infection as well as vaginosis and vaginitis.

Disruption can result in inflammatory conditions such as candidal or bacterial vaginitis. Even a disruption in the normal balance of hydrogen peroxide-producing Lactobacilli species can result in a overgrowth of other Lactobacilli, causing symptoms. This condition is characterized by a cytolytic vaginosis and is associated with a particularly long or short form of Lactobacillus. (15) These long or short Lactobacilli do not produce hydrogen peroxide. (3) This Lactobacilli imbalance mostly occurs after treatment with various antimicrobial agents, apparently through inhibition of hydrogen peroxide-producing Lactobacilli, allowing overgrowth of the other Lactobacilli.

### Alteration of the Vaginal Ecosystem

Many factors can alter the vaginal ecosystem. Hormonal changes, tampons, sexual activity, contraceptives, other medications, diseases and even emotions can potentially alter the vaginal epithelium or the microflora.

Normal monthly cyclic changes influence the estrogen effect on vaginal epithelium and the amount

and composition of endocervical secretions. Menstrual flow through the vagina results in changes in pH and oxidation-reduction potential. The vaginal pH increases to 7.0 with the onset of flow, then drops sharply to normal by the 4th day. (6) There is a documented increase of gram positive cocci, Enterobacteria, Bacteroides and a decrease of Lactobacilli during menses. (6) It seems likely that frequent uterine bleeding may alter the flora.

Tampons, especially superabsorbant types and those with plastic applicators, have been shown to result in microlacerations of the vaginal epithelium, and chemicals present in tampon products may influence the microflora growth. (16) Oxygen levels at the vaginal surface increase suddenly with the insertion of tampons and don't decrease for hours. (6) This could predispose a woman to infections with aerobic flora such as gram-positive cocci and enterococci. In fact, there is a study that shows an increased rate of isolation of coagulase negative staphylococci in tampon users. (17)

The mechanical and chemical stresses on the vaginal environment from coitus can cause transient alterations in the microflora. Semen increases the vaginal pH dramatically. Research has shown that vaginal pH takes 8 hours to return to normal after ejaculatory intercourse. (18) Frequent sexual activity could lead to prolonged alkaline conditions in the vagina. One researcher theorized that women who have sexual intercourse more than twice a day may seldom possess a normal vaginal ecosystem. (18) Semen also inhibits the local immune defense mechanism of the vagina, including complement. (2) These factors may help to explain why vaginosis and candidal vaginitis appear to be sexually transmitted even though the male partner is not colonized. The change in the physical and chemical conditions in the vagina results in an imbalance of the microflora, rather than a sexual transmission of microbes.

Related to sexual activity is use of local contraceptives. Spermicides have been shown to preferentially inhibit hydrogen peroxide-producing Lactobacilli. (19,20) Diaphragm use has been associated with alteration of the vaginal ecosystem: increased pH, abnormal fatty acid content, increased colonization of the introitus by E. coli, increased prevalence of bacterial vaginosis, as well as symptoms of acute UTI. (21) A more recent study showed increased vaginal colonization with E. Coli, group B streptococci, group D streptococci and other gram negative uropathogens in women who used a diaphragm with spermicide. (22) These women also had increased Candida colonization and decreased Lactobacillus colonization. Since high concentrations of hydrogen peroxide-producing Lactobacilli are both viricidal to HIV-1 and inhibited by spermicides, the clinician might question the wisdom of spermicide use in women at risk for exposure to HIV.

Oral contraceptives and hormone replacement therapy are known to affect the vaginal epithelium and can alter the vaginal flora. It has been observed that menopausal women using estrogen replacement therapy have higher levels of Lactobacilli than untreated women. (23) Botanicals such as Cimicifuga racemosa, which has effects on the vaginal epithelium similar to estrogen (24), have the potential to affect the vaginal flora as well.

Some antibiotics may be especially likely to cause alterations in the composition of the vaginal flora. In particular, the use of long term broad spectrum antibiotics is associated with candida overgrowth. Long term cytostatic, corticosteroid, antiviral and antifungal therapy can also alter the vaginal flora. (2) Disease states, such as diabetes and AIDS, have a documented effect on the vaginal ecosystem, resulting in overgrowth of Candida.

Douching will alter the conditions in the ecosystem, at least temporarily, causing various changes depending on what is used. (1) Infrequent or short term douching may not have the same effect as would regular douching.

Women with cervical intra-epithelial neoplasia have an increased incidence of altered cervical flora including higher levels of colonization with Gardnerella, Mycoplasma and Bacteroides. (25) This information raises the question of whether the altered flora may in fact be at least partially responsible for the neoplasia. Nitrosamines, produced by these bacteria, have known oncogenic potential. (2,26) In addition, Gardnerella produces a hemolysin capable of destroying leucocytes. (1) Inhibition of the immune system might allow for HPV to effect neoplastic changes. The viricidal effect on HIV-1 by hydrogen peroxide-producing Lactobacilli might be important in HPV infection as well.

Emotional, psychological and spiritual factors may influence the ecosystem. Northrup suggests that women with chronic vaginal problems may be experiencing feelings of violation in a relationship. (27)

It is remarkable that most of the time all of the above mentioned factors are compensated for by the vaginal ecosystem, and its dynamic balance is maintained. Possibly a combination of factors may be necessary to produce an imbalance. Treatment of imbalance should have as its goal returning the system to its normal dynamic equilibrium. Assisting the vaginal ecosystem in returning to normal may be helped by removing causes of imbalance, re-establishing a normal vaginal epithelium and re-establishing normal biotic flora.

Removing or changing factors which are known to alter the vaginal ecosytem might be all that is needed to allow the system to return to normal. Careful history in women with vaginosis or vaginitis will help to identify possible contributing factors. Removing possible causes of imbalance makes sense as the first step in restoring balance. Re-establishing normal vaginal conditions by acidification with lactic acid has been shown to be helpful. This local treatment restores normal vaginal acidity and facilitates recolonization with Lactobacilli. (28,29) Another local treatment might be the use of dilute hydrogen peroxide to decrease the levels of pathogens. One study indicates that hydrogen peroxide could be substituted for the hydrogen peroxide-producing Lactobacilli. (11) In postmenopausal women, systemic or local treatment with estrogens (30), or the use of phytoestrogens might be helpful in changing the epithelium to restore balance.

Re-establishing the dominance of hydrogen peroxide-producing Lactobacilli may be an effective therapy to restore the ecosystem to balance. There are a number of studies utilizing yogurt or Lactobacillus that have demonstrated some effectiveness in the restoration of normal flora. (31-36) Further studies are needed to see if biotherapeutic agents such as an adherent strain of hydrogen peroxide-producing

Lactobacillus can be effective in restoring the vaginal ecosystem. (3,9,37)

Treatment with anti-microbials, both pharmaceutical and botanical, to decrease or eliminate pathogens, should be prescribed carefully to exclude agents which decrease or eliminate the hydrogen peroxide-producing Lactobacilli. (4)

Understanding the dynamics of the vaginal ecosystem is far from complete. Additional research is needed to better comprehend the normal balance in the vagina, the effects of external factors, and the ways in which the normal equilibrium can be restored.

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