

**PATHOMORPHOLOGICAL CHANGES ON CONCHAE OF PIGLETS EXPERIMENTALLY
INFECTED WITH BORDETELLA BRONCHISEPTICA**

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Atrophic rhinitis was provoked in two or three-day old piglets by intranasal application of a culture of a virulent strain of B. bronchiseptica. B. bronchiseptica could be isolated from the lungs until day 60, from the trachea until day 75 and from the conchae until day 120. The causative agent could be isolated from the ethmoid sinus until day 165 of the infection. Clinical symptoms were evident on day 5 after infection and were noticeable until day 60. Macroscopic changes on conchae appeared as hyperemia, the presence of haemorrhagic content and different degrees of conchae atrophy (1-5) with deformation of the nasal septum. Atrophic changes were evident on day 23 of the infection and could be noticed until the end of the investigation. Changes on the lungs of animals that died and sacrificed animals appeared as fibrous pneumonia on the apical and cardiac lobes of both lungs. Pathohistological changes which are characteristic for atrophic rhinitis were found in all infected animals from day 12 of the infection until the end of the experimental period. The type of changes depended on the infection stadium and they appeared as epithelial proliferation, disappearance of cup-shaped cells, cell losses and destruction of bone trabeculae.

Key words: piglets, B. bronchiseptica, isolation, damage, conchae

INTRODUCTION

The etiology of atrophic rhinitis is very complex. Since the disease was described for the first time in Germany, three theories about it have arisen the concept of a deficient diet, genetic factors and infectious agents. After the report of Switzer et al. (1956) about the successful experimental provoking of conchae atrophies and piglet pneumonia, *B. bronchiseptica* has been considered to be the primary causative agent of the disease.

Letter on the level of success in provoking the disease ranged between 50 and 100%. Thusi Maeda et al. (1976) and Baetz et al. (1974) found a severe infection, with conchae atrophy of degree 5. Apart from the conchae changes, pneumonia and endocarditis were also registered. Kemeny et al. (1972) inoculated 6-10-day-old piglets intranasally with nasal washings of naturally infected animals and they found conchae atrophies of weaker or stronger intensity (81%). The authors emphasize that the difficulties that appear when provoking the disease in experimental conditions are probably a consequence of the lack of some factors that exist in natural infections. Martineau et al. (1982) found that there is a minimum infectious dose of the agent for occurrence of the disease, that is 3×10^5 bacteria/ml. Greater doses of inoculum, 9×10^9 /ml, provoked disorders of the general condition and symptoms characteristic for the acute stadium of atrophic rhinitis in the infected animals. On day 30 after infection, significant conchae atrophies were registered on the cross section. Except for the characteristic pathohistological changes, symptoms of snout deformation were, not found in animals infected with high doses of inoculum. The observations of Brassina et al. (1976) and Tomoe et al. (1976) are similar. They did not register clinical signs which were typical for the chronic form of atrophic rhinitis in pigs with conchae atrophies of high degree.

In most cases atrophic changes have primarily been observed on the ventral concha, and then on the dorsal and ethmoid concha. Done et al. (1976) described a standard system that many researchers used for evaluation of changes on the cross section of the snout of the affected animals. In postmortem investigations, changes on the lungs of pigs with atrophic rhinitis have also been observed.

A histological investigation shows most often a reduction of the cilia number on the nasal mucous membrane and an epithelium hyperplasia with infiltration of mononuclear cells. A reduction of bone trabecula is noticeable three weeks after infection. Martineau et al. (1982) pointed to characteristic changes on the bones in the form of cartilaginous metaplasia of conchae bones. In the area of intensive metaplasia parts without osteoblasts were found. Progressive degenerative changes were observed in osteoblasts and osteocytes in the form of enlargement of mitochondria, spreading of the cisterns of the endoplasmatic reticulum and changes on the Golgi apparatus, which contributes to the development of osteoporosis of conchae bones. Sekiya et al. (1989) found by electron microscopy that *B. bronchiseptica* settles the interciliary space of epithelial cells already 20 hours after infection. They noticed that the cilia membrane breaks, the cilia become swollen and disappear later. The changes in the chronic stadium are characterized by lymphocyte infiltration and fibrosis of the nasal mucous membrane as well as by formation of new bone tissue and hyperostosis.

MATERIAL AND METHODS

Experimental animals: For this investigation, three pregnant gilts (ABC) originating from the experimental herd of the Institute were used. Pregnant gilts were examined twice before the beginning of the experiment, bacteriologically

and serologically. The examination was repeated on the day of farrowing. The animals were kept under the same conditions and were given food without antibiotics.

Out of the total of 33 piglets born, 30 were used in these investigations. Immediately after farrowing, the piglets were marked and they were weaned at the age of eight weeks.

Preparing of inoculum: A 24-hour-old broth culture of the virulent strain of *B. bronchiseptica*, which was chosen for the experimental infection, was inoculated in the quantity of 0,1 ml into the yolk sac of 6-day-old embryonating chicken eggs. The inoculated eggs were incubated at 37°C and candled each day. Embryos dying after 24 h incubation were incubated an additional 24 hours. Yolk fluids were harvested and tested for purity and then the prepared inoculum was stored frozen at -20°C.

The piglets were infected intranasally with 0,5 ml of the inoculum in each nostril in the phase of inhalation. Out of 30 piglets, 22 were inoculated twice at 2 and 3 days of age, while 8 animals lived in co-habitation. The experimental animals were investigated at 15-day-intervals and the whole experiment lasted 165 days.

Bacteriological investigations: From the sacrificed piglets or the piglets that died, swabs of conchae, ethmoid sinus, trachea as well as a part of the lungs were taken for bacteriological investigation.

Culture media: For cultivating of *bordetella* blood agar containing penicillin, nitrofurantion and nystatin as well as MacConkey agar containing penicillin, ceporex and nystatin were used (Vidić et. al. 1993.) Swabs were planted by the method of exhausting, and a portion of lung (cca 2 g) was taken, homogenized with 2 ml of the PBS solution, with the addition of heated sand, and planted on culture media. The media were checked daily and from characteristic colonies further identification of bacteria was performed.

Clinical investigations: Experimental animals were observed daily during the first three weeks after the experimental infection and afterwards twice a week. Their general condition and the presence of respiratory disorders: nasal discharge, sneezing, conjunctivitis, cough and the presence of snout deformation that are characteristic for atrophic rhinitis were observed.

Morphological investigations: These investigations included animals that were sacrificed at the anticipated time intervals as well as the piglets that died. Cross sections of the nose at the height of the first or the second premolar tooth were made. The degree of pathological damage to the shell-shaped bones and the nasal septum were macroscopically estimated, using the evaluation system from 0 to 5, which was described by Done et al. (1976).

Pathohistological investigations: Portions of the nose parts were fixed in 10% neutral formalin. After the standard procedure pieces of conchae were molded in paraffin. Paraffin sections of 5 mm thickness were stained with HE and Weigert van Gijssen stain and observed under the microscope (x252).

RESULTS

During the investigation 9 animals died: on day 6 after infection one piglet died because of contusions, while 3 piglets died on days 54, 55 and 57 because of enterotoxemia. Five piglets died between day 12 and day 25 after infection (table 1). They showed a serious disease picture, nasal secretion, conjunctivitis, very intensive cough, heavy breathing and loss of appetite.

Table 1. Results of clinical, morphological and bacteriological investigations of animals that died during the experimental periods

No. of the piglet	Day aft. infe.	Clinical symptoms	Macroscopically		Microscopically	Isolation of <i>B. bronchiseptica</i>			
			conchae	lungs		conchae	ethm.	trach.	lungs
I 3	6	—	—	—	—	+	+	+	—
I 1 ^L	12	Ns. Cn. Co. D.	Hem.sec.	Pneum.	+	+	+	+	+
I 2 ^D	12	Ns. Cn. Co. D.	Hem.sec.	Pneum.	+	+	+	+	+
I 1/1	14	Ns. Cn. Co. D.	Hem.sec.	Pneum.	+	+	+	+	+
I 1/3	23	Ns. Cn. Co. D.	2	Pneum.	+	+	+	+	+
C 3/3*	25	Ns. Cn. Co. D.	4	Pneum.	+	+	+	+	+
C 2 ^R	54	—	2-3	—	+	+	+	+	—
I 1	55	—	4	—	+	+	+	+	+
I 7	57	—	2	—	+	+	+	+	—

I - infected piglets
 C - piglets in co-habitation
 Ns - nasal secret

Cn - conjunctivitis
 Co - cough

D - dispnea
 * - pericarditis

From the data presented in table 1, it can be seen that *B. bronchiseptica* was isolated from the conchae, the ethmoid sinus, the trachea and the lungs of piglets that died between days 12 and 25 from the infection. The dead piglets showed characteristic respiratory disorders, pneumonia was registered on the sections, and morphological changes that are typical for atrophic rhinitis were found by histological examination of conchae. *B. bronchiseptica* was also isolated from the lungs of the piglet that died on day 55 after infection with conchae atrophies of degree 4, present but there were no morphological changes on the lungs.

Sneezing and serous discharge from the nose were observed in infected animals 5-10 days after infection. Conjunctivitis was noticed on day 12 after infection and it was present with greater or less intensity until day 60. Coughing was registered on day 8 and many animals coughed until day 20-25 after infection, with obvious heavy breathing. After day 60 no clinical symptoms characteristic for atrophic rhinitis were noticed (table 2). The clinical symptoms in animals that lived in co-habitation were very similar to those in inoculated piglets. They appeared already after 15 days and one piglet died on day 25. Snout deformations were not found in the infected animals.

Table 2. Results of clinical, morphological and bacteriological investigations on the sacrificed animals

No. of the piglet	day after infection	Clinical signs	Conchae atrophy	Microscopically	Isolation of <i>B. bronchiseptica</i>			
					conhoe	ethm.	trach.	lungs
I 5	15	Ns.Cn.Co.	—	+	+	+	+	+
C 1/2	15	Ns.Cn.Co.	—	+	+	+	—	—
I 5 ^R	30	Ns.Cn.Co.D	5	+	+	+	+	+
I 4 ^{L*}	30	Ns.Cn.Co.D	4	+	+	+	+	+
I 2	45	Ns.Cn.	4-5	+	+	+	+	+
C 2/2	60	Ns.Cn.	4	+	+	+	+	+
I 1 ^{D**}	60	Ns.Cn.Co.D	4	+	+	+	+	+
C 8	75	—	2-3	+	+	+	+	—
C 9	90	—	1-2	+	+	+	—	—
I 4	90	—	4	+	+	+	—	—
I 5	90	—	1-3	+	—	+	—	—
I 6	90	—	2	+	+	+	—	—
C 3 ^R	120	—	1	+	—	+	—	—
I 3	120	—	—	+	+	+	—	—
I 9	135	—	—	+	—	—	—	—
C 6	165	—	1	+	—	—	—	—
I 1	165	—	2	+	—	+	—	—
I 2	165	—	2	+	—	—	—	—
I 8	165	—	4	+	—	—	—	—
C 1 ^R	165	—	1	+	—	+	—	—
I 4 ^R	165	—	3-4	+	—	—	—	—

I - infected piglets
C - piglets in co-habitation
Ns - nasal secret

Cn - conjunctivitis
Co - cough
D - dyspnea

* - pneumonia
** - pneumonia, pericarditis

In the sacrificed animals, *B. bronchiseptica* was isolated in one case from the trachea and lungs on day 15 after infection (table 2). *B. bronchiseptica* was isolated from the conchae, the ethmoid sinus, the trachea and the lungs of all piglets that were sacrificed on days 30, 45 and 60 after infection. After day 60 negative results were obtained after bacteriological investigation of the lungs. It could also be seen (table 2.) *bronchiseptica* was isolated from the ethmoid sinus in 4 animals on days 90, 120 and 165 after infection, while at the same intervals the bacteriological result for the conchae were negative.

Pathomorphological changes in the experimental animals, in infected ones as well as in those who lived in co-habitation, were characteristic for atrophic rhinitis. In the nasal cross sections, the following macroscopic changes could be observed: hyperaemia of the mucous membrane, the presence of haemorrhagic content, atrophic changes on the conchae were noticed on day 23 after infection (degree 2) while on day 30 they had reached degree 4-5. Atrophic changes of

different degree were registered on the conchae until the end of the investigation period (table 2).

In the animals that died (1, 2d, 1/1, 1/3, table 1), apart from changes on the conchae, hyperaemia of the tracheal mucous membrane and an increased quantity of gelations secretion were also observed. Changes on the lungs could be seen in the apical and the cardiac lobe of both lungs in the form of fibrous pneumonia. Pericarditis was found in one animal.

Morphological changes in piglets on days 12, 14 and 15 after infection: A moderate asymmetry of the conchae with a copious haemorrhagic content (figure 1a) was observed. Proliferation of the epithelium with the appearance of a multirow epithelium composed of irregularly assigned cells mostly on the ventral conchae was found by histological examination. Disappearance of cup-shaped cells and a decrease of cell number were observed. A cell infiltrate typical for an acute inflammation was found in the mucosa (figure 1b).

Morphological changes in piglets on days 23, 25 and 30 after infection: Conchae atrophy of degrees 4 and 5 was found in 3 animals, while atrophic changes were of lower intensity in one animal (figure 1c). An outstanding hyperplasia of the epithelium with cell infiltrate was observed by histological investigation. Cup-shaped cells had almost disappeared, i.e. these cells could not be detected any more or they were very reduced in number. In the lamina propria proliferation of the connective fibers was observed. Bone trabeculae became very thin and their destruction was noticed (figure 1d).

Changes on the conchae in animals on day 45 after infection appeared in the form of atrophies of the degree 4-5. Deviation of the nasal septum was present (figure 1e). Histological examination showed that some parts of the epithelium were completely destroyed, while atrophy of the epithelium was registered in the remaining areas. Cup-shaped cells had disappeared, and cuboid cells with large nuclei containing compact chromatin were noticed. Blood vessels were cavernous and filled with erythrocytes. Bone trabeculae were thin and among them mesenchymal tissue and islets of chondroblasts were observed (figure 1f).

Two months after infection, conchae atrophy of degree 4 was observed in the sacrificed animals (figure 1g). A copious cell infiltrate in the mucosa was noticed histologically. Blood vessels were dilated and among them the tissue was copiously infiltrated with lymphocytes. Arterioles with destroyed walls and muscle layers that had become extremely thick were noticeable. Muscle and endothelial cells had become swollen (figure 1h). Bone trabeculae were very thin, irregularly disposed and surrounded by osteoblasts (nondifferentiated fibroblasts).

Conchae atrophy of degree 2-3, exhibiting hyperaemia and haemorrhages, were observed on day 75 after infection (figure 2). Histologically, a partially destroyed epithelium was noticed. The nasal glands were hyperplastic and copiously infiltrated with lymphocytes (figure 2 j). Small blood vessels had become thick and bone trabeculae osteoblastic.

Animals that were investigated 90 days after infection showed conchae atrophy of different degree (1-4) (figure 2 k). Microscopic examination showed that the epithelium was partially destroyed and in some parts cuboid cells were

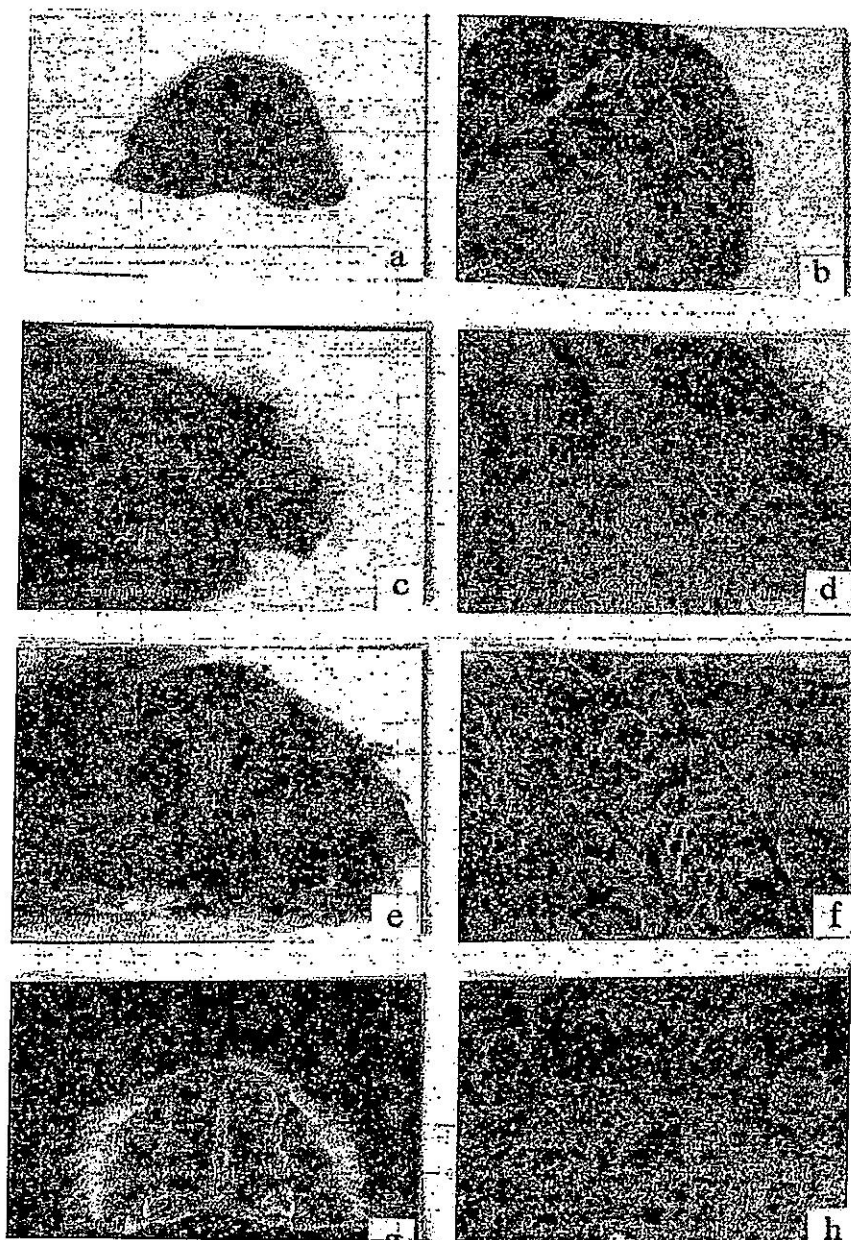


Figure 1. Morphological changes of conchae in experimentally infected piglets, 15-60 days p/i (a-h)

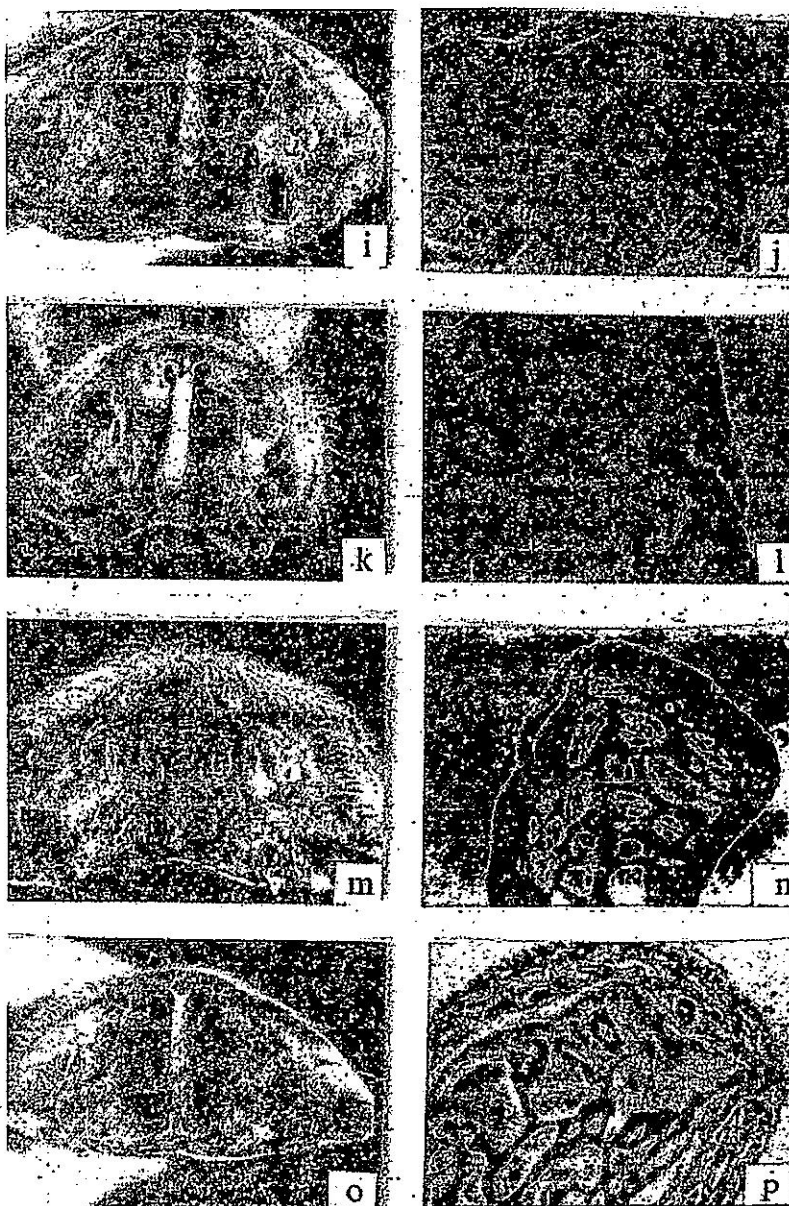


Figure 2. Morphological changes of conchae in experimentally infected piglets, 75-165 days p/i (i-p)

obvious. The connective tissue in lamina propria was hyalized and copiously infiltrated with lymphocytes. Blood vessels were hyperaemic and here and there bleeding could be seen. Nasal trabeculae had almost disappeared and among the rest of the bone trabeculae, which had become very thin, connective tissue of the cellular type with numerous nondifferentiated osteoblasts were observed (figure 21).

Atrophic changes were moderate in the animals that were examined on day 120 after infection (figure 2 m), but conchae hyperaemia was registered. Histologically, it could be seen that the epithelium was partially desquamated and stratified. Numerous connective fibers with copious mononuclear infiltration were noticed in lamina propria. Blood vessels were cavernous, dilated and filled with blood. Bone trabeculae had become thin and a lacunal resorption of bone tissue was registered (figure 2n).

In animals that were sacrificed at the end of the experiment (on day 165 after infection) atrophies of degree 1 to 4 (figure 2 o) were noticed, and also conchae hyperaemia in 3 piglets. Histologically, it was found that the epithelium had atrophied and the nasal glands showed hyperplasia. Connective fibers were copiously represented and infiltrated with lymphocytes. The walls of the blood vessels were thick, which led, apart from swelling and multiplying, to an obliteration of blood vessels. Bone trabeculae were very thin and contained connective fibers with sinexions. Resorption of bone tissue was also observed (figure 2p).

DISCUSSION

In contrast to the characteristic clinical picture in naturally infected animals, the typical picture of atrophic rhinitis is rare in experimentally infected animals. In our investigations no snout deformations were found in spite of the conchae atrophies of degree present. Similarly to our results, Brassina et. al. (1976), found a high degree of conchae atrophy, but no snout deformations in piglets.

The piglets that died previously showed a severe picture of the disease, a copious mucous nasal discharge, conjunctivitis, a very intensive cough, hindered breathing and loss of appetite. Maeda et al. (1976) and Baetz et. al. (1974) also reported a severe disease form after experimental infection.

In dead animals, changes on the lungs in the apical and cardiac lobe of the both lungs in the form of fibrous pneumonia were found. Fois et. al. (1977), and Nakagava et. al. (1974,) reported similar results, whereas Perfuma et. al. (1980), consider that *B. bronchiseptica* can cause pathological changes on the lungs in animals in bad health and raised in unsuitable conditions. Straw et. al. (1983) found no correlation between the appearance of pneumonia and atrophic changes on the conchae. On the contrary, Flesja (1980) reported a high frequency of pneumonia in pigs that had atrophic changes on the conchae.

Clinical symptoms in piglets in co-habitation were similar to those in infected piglets and could be observed on day 15 after the beginning of the experiment.

Baetz et. al. (1974), Mihajlović et. al. (1978) and Shimizu et al. (1971.) reported the possibility of isolation of *B. bronchiseptica* after experimental infec-

tion. These authors isolated *B. bronchiseptica* in 100% of cases or 3,4 weeks after infection, while they obtained mostly negative results from nasal swabs after 3 months. However, *B. bronchiseptica* could be isolated from the ethmoid sinus. Tomoe et al. (1976). reported the elimination of *B. bronchiseptica* from accessible nasal parts with aging of the piglets. Duncan et al. (1966). consider that the tendency of the decrease of *B. bronchiseptica* in the nasal cavity can be explained by tissue resistance and its influence on bacterial multiplication on the surface of the epithelium.

In our investigation, *B. bronchiseptica* could be detected for the longest period in the ethmoid sinus (table 2). *B. bronchiseptica* was isolated from the ethmoid sinus in 4 animals on days 90, 120 and 165 after infection, whereas at the same time the bacteriological result for the conchae was negative. Kemeny (1970) and Shimizu et. al. (1971) etc. obtained similar results, which is very important from the standpoint of epizootiology. According to the results of Switzer et.al. (1975). breeding animals are latent carriers in 10-15% of cases. Because of this, examination of nasal swabs of older categories of swine and sows has limited importance for the diagnostics. On the base of the, it can be concluded that a negative bacteriological result does not mean also an absence of the infection and that numerous repeats are necessary, which confines the results of Farrington et. al. (1977).

Bacteriological investigations of infected piglets and piglets in co-habitation, showed no great differences. *B. bronchiseptica* was isolated from all animals that lived in co-habitation with the infected ones on day 15 after infection. Smith et. al. (1982) found that the infectious agent transmitted very fast from the experimentally infected piglets to other animals in the litter. Such piglets showed symptoms of the disease, already on day 9 from the infection whereas Giles et al. (1980) registered already spontaneous infection in piglets that were in contact with infected animals from the same or a neighbour in litter after 3 days.

Atrophic changes of different intensity were found in the majority of the infected animals. Out of 30 experimental animals, macroscopic changes were not noticed in two piglets on day 120 and in another on day 135 after infection, while microscopic changes were registered and *B. bronchiseptica* was isolated. Mihajlović et. al. (1978) also reported the absence of atrophic changes in a certain number of experimentally infected piglets. Duncan et. al. (1966) and Smith et al. (1982) demonstrated reparation processes in infected animals in later stages of the infection. Similarly to our results, both Kemeny (1972) and Martineau et al. 1982. found more intensive changes on the conchae in piglets that were infected at the age of 3 days than in piglets that were infected at the age of 4 weeks. Thus young animals are sensitive to infection with *B. bronchiseptica*. With growing older, piglets become resistant, so that older animals can be infected but there is much less possibility for severe atrophic changes to appear. Ross et. al. (1966.) found conchae atrophy in 94% of the animals that were infected at the age of 3 days and only in 66% of the animals infected at the age of 4 weeks.

We noticed microscopic changes on the conchae on day 12 of the infection and they could be observed in all infected animals until day 165. Some of these changes were present during the whole investigation period. This particularly refers to hyperplasia of the epithelium of the nasal mucous membrane and the bone trabeculae that became thin. In our investigations, in the early stage of the infection, changes appeared in the form of epithelial proliferation with the appearance of a multirow epithelium. Disappearance of cup-shaped cells and a decreased number of cilia or their absence was noticed. Harris et al. (1971) consider that such destruction of cilia is the reason for the ineffective resistance of the mucociliar apparatus, which is significant for bacterial colonization. Sekya et al. (1989.) found by use of electron microscopy that *B. bronchiseptica* settle the intraciliary space of the epithelial cells already 20 hours after infection. Afterwards, cilia became swollen and disappeared. We noticed changes on bone trabeculae on day 30 after infection. Bone trabeculae became very thin and their destruction and the presence of mesenchymal tissue and osteoblasts could be observed. The presence of osteoblasts indicates degenerative changes, and, according to Duncan et al. (1966), these cells are responsible for the resorption of bone tissue. Microscopic changes occurred on blood vessels in the form of cavernous changes or a thick muscle layer. Apart from the cited changes, lymphocyte infiltration and the presence of sintexion were observed in the chronic stage of the disease.

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PATOMORFOLOŠKE PROMENE NA KONHAMA PRASADI VEŠTAČKI INFICIRANIH SA *B. BRONCHISEPTICA*

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SADRŽAJ

Intranasalnom aplikacijom kulture virulentnog soja *B. bronchiseptica* reprodukovali smo atrofični rinitis kod prasadi stare dva, odnosno tri dana. Klinički simptomi ustanovljeni su 5. dana od infekcije i mogli su se uočiti do 60. dana. *B. bronchiseptica* je izolovana do 60. dana iz pluća, a do 75. dana infekcije iz traheje. Iz etmoidalnog sinusa uzročnik se mogao izolovati do 165. dana infekcije.

Makroskopske promene na konhama ispoljavale su se u vidu hiperemije, prisustva hemoragičnog sadržaja i atrofija konhi različitog stepena (1-5) sa krivljenjem nosne pregrade. Atrofične promene uočene su 23. dana od infekcije i mogle su se ustanoviti do kraja ispitivanja. Promene na plućima kod uginulih i žrtvovanih životinja manifestovale su se u vidu fibrinozne pneumonije na apikalnom i kardijačnom lobusu oba plućna krila. Patohistološke promene karakteristične za atrofični rinitis ustanovljene su kod svih inficiranih životinja, od 12. dana infekcije do kraja oglednog perioda. Vrsta promena zavisila je od stadijuma infekcije i one su se ispoljavale u vidu proliferacije epitela, iščezavanja peharastih ćelija, gubitka cilija i razaranja koštanih gredica.