JOURNAL OF CLINICAL MICROBIOLOGY, Apr. 1989, p. 743–747
0095-1137/89/040743-05$02.00/0

Vol. 27, No. 4

Biotypes and O Serogroups of *Escherichia coli* Involved in Intestinal Infections of Weaned Rabbits: Clues to Diagnosis of Pathogenic Strains

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Received 8 July 1988/Accepted 9 January 1989

A total of 575 *Escherichia coli* strains isolated from weaned rabbits experiencing diarrhea in 119 French commercial farms were tested for O serogroups. The results showed a strong predominance of serogroup O103 strains. A sample of 126 strains were further checked for simplified biotypes by using five carbohydrate fermentation reactions. Of 72 O103 strains, 70 were shown to belong to biotypes characterized by a rhamnose-negative reaction. Four of nine serogroup O68 strains also showed this type of reaction. Thirty-nine strains, representative of the serotypes and biotypes found, were further tested for experimental pathogenicity in weaned rabbits and for antibiotic susceptibility. All the rhamnose-negative strains produced life-threatening watery or hemorrhagic diarrhea, whereas rhamnose-positive strains induced only mild diarrheic syndrome without any mortality or no clinical signs at all. Rhamnose-negative, highly pathogenic strains did not belong to related antibiotypes. We think that O serogrouping together with biotyping, or even rhamnose fermentation testing, may be an important clue in the diagnosis of enteropathogenic strains from rabbits in France, permitting rapid identification of highly pathogenic strains and leading to improved prognosis and treatment.

For the last few years, increasingly frequent epizootics of noncoccidial life-threatening enteric diseases have been encountered in industrial rabbit-fattening farms in France, with considerable economic involvement owing to weight loss in diarrheic animals and to high mortality rates (20 to 30%). These enteric diseases are associated in each case with the proliferation of *Escherichia coli* in ileocecal contents of weaned rabbits. French as well as other researchers have isolated pathogenic *E. coli* strains with which they could reproduce the disease by feeding them to weaned rabbits (2, 5, 8, 14, 15, 17).

In 1984 and 1985, an epidemiologic survey in 58 French rabbit-fattening farms with diarrhea problems led us to conclude that there was a peculiar frequency of *E. coli* strains belonging to serogroup O103 (4). One O103 strain isolated in 1984 (strain B10) allowed one of us (R.C.) to produce experimental enteritis in weaned rabbits (3). This strain does not produce heat-stable or heat-labile enterotoxin and is not enteroinvasive. It adheres in vivo to ileal epithelium and seems to be responsible for destructive lesions of the epithelium, as judged by histologic examination (3). It is probably related to the enteropathogenic *E. coli* group, as are most of the pathogenic strains isolated from rabbits (9). However, non-O103 strains may be isolated from diseased animals (4). Furthermore, *E. coli* is a frequent component of the gut flora in healthy rabbits, although usually at low rates (7). Thus, serogrouping alone is not a sufficient clue to the diagnosis of strains pathogenic for rabbits. Therefore, since reproducing the disease in healthy rabbits with each field isolate is time-consuming and economically impossible, we tried in the work presented here to correlate experimental pathogenicity with other isolate markers, such as biotypes and antibiotypes, which might be complementary to serogroup determination.

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MATERIALS AND METHODS

***E. coli* strains.** A total of 575 *E. coli* strains isolated from the cecal contents of 175 diarrheic weaned rabbits between 1984 and 1987 were used in this study. The diseased animals were gathered from 119 industrial fattening farms in 34 French administrative departments. All these strains were tested for O serogroup. A restricted panel of 126 strains, representative of all the farms (at least 1 strain per farm), were selected for biotyping studies. Then, 39 strains belonging to the different serogroups and biotypes encountered were further checked for antibiotic susceptibility and ability to produce clinical signs of diarrhea, weight loss, and mortality after experimental oral administration to healthy weaned rabbits.

Serogrouping. A panel of 11 different anti-O sera were prepared by immunization of rabbits with reference *E. coli* strains from the Institut Pasteur collection (Paris, France) by a previously described technique (4) and according to standard methods (11). Sera used in routine serogrouping were anti-O2, anti-O8, anti-O15, anti-O18, anti-O20, anti-O49, anti-O68, anti-O85, anti-O103, anti-O128, and anti-O132. The range of O specificities tested was chosen according to the peculiar frequency of these serogroups in rabbits (4). For typing, an 18-h culture of each strain on Trypticase soy agar (BBL Microbiology Systems, Cockeysville, Md.) was suspended in saline and heated for 1 h at 100°C. Typing was done by slide agglutination.

Biotyping. Fermentation of carbohydrates was tested on phenol red agar base (Difco Laboratories, Detroit, Mich.), supplemented with 1% of the appropriate carbohydrate, in square Integrid petri dishes (Falcon). Strains were inoculated as spots on the medium, and the results were read after 6, 24, and 48 h of incubation at 37°C. Selected carbohydrates were chosen according to the results of Okerman and Devriese (10). Initially, we tested the following carbohydrates: D-cellobiose, dulcitol, maltose, D-raffinose, L-rham-

TABLE 1. O serogroups identified in *E. coli* field isolates from 175 weaned rabbits at 119 French industrial farms with enteritis and mortality problems (1984 to 1987)

O serogroup	No. of strains		
	Isolated (n = 575)	Biotyped (n = 126)	Tested for pathogenicity (n = 39)
2	17 (3)[a]	7	5
15	1 (0.2)	1	1
68	23 (4)	9	8
85	8 (1.4)	2	1
103	308 (53.6)	72	17
128	19 (3.3)	4	2
132	33 (5.7)	12	5
NI[b]	166 (28.9)	19	

[a] Percentages are shown in parentheses.
[b] NI, Rough strains (n = 30) or strains that were untypeable with available antisera (n = 136).

TABLE 2. Biotypes found in *E. coli* isolated from weaned rabbits with diarrhea

Biotype code[a]	Fermentation[b] of:				
	Sorbose	Dulcitol	Raffinose	Sucrose	Rhamnose
6	−	+	+	−	−
12	−	−	+	+	−
13	+	−	+	+	−
14	−	+	+	+	−
16	−	−	−	−	+
18	−	+	−	−	+
19	+	+	−	−	+
24	−	−	−	+	+
26	−	+	−	+	+
27	+	+	−	+	+
28	−	−	+	+	+
29	+	−	+	+	+
30	−	+	+	+	+
31	+	+	+	+	+

[a] Biotype codes are explained in Materials and Methods.
[b] Symbols: −, 0; +, 1 (sorbose), 2 (dulcitol), 4 (raffinose), 8 (sucrose), or 16 (rhamnose).

nose, sorbose, sucrose, and L-xylose. Cellobiose, maltose, and xylose gave nondiscriminant results and were not included in the typing scheme. Biotypes or biotype codes were defined by the sum of the numbers given by positive fermentative reactions (see Table 2). For instance, biotype code 6 strains are 0, sorbose negative; 2, dulcitol positive; 4, raffinose positive; 0 and 0, sucrose and rhamnose negative.

Antibiotic susceptibility testing. Standard antibiotic susceptibility tests were done by the method of Bauer et al. (1) on Mueller-Hinton agar with antibiotic disks purchased from Diagnostics Pasteur, Marnes-la-Coquette, France. Antibiotics tested were ampicillin, amoxicillin, streptomycin, kanamycin, gentamicin, chloramphenicol, oxytetracycline, erythromycin, spiramycin, colistin, flumequine, sulfafurazole, and trimethoprim-sulfamethoxazole.

Experimental infections. Each strain tested for pathogenicity was orally inoculated to a group of two to four (usually three) weaned 37-day-old New Zealand rabbits free of coccidias. The animals of each group were reared in the same metallic cage, fed with a coccidiostatic-supplemented commercial feed, and watered ad libitum.

Bacterial suspensions in saline were prepared from 24-h cultures on Trypticase soy agar. Each rabbit was given a 2-ml dose (approximately $8 \cdot 10^9$ CFU) by oral canula.

The animals were checked daily for clinical signs of diarrhea and dehydration and for mortality. They were weighed twice a week. Dead animals were autopsied. Macroscopic lesions of the digestive tract were noted. *E. coli* counts were done on the cecal contents by the MacConkey agar dilution technique (4). For each rabbit, three strains of *E. coli* were isolated on Trypticase soy agar and then serogrouped and biotyped. Coccidial controls were also performed, without showing concurrent infestation.

RESULTS

O serogroups. More than half of the 575 *E. coli* strains tested belonged to serogroup O103 (Table 1). Less frequent serogroups included O132 (5.7%), O68 (4%), O128 (3.3%), and O2 (3%). Among the 166 ungroupable strains, 30 were rough strains and 136 could not be grouped with the available antisera. In nearly all cases, all the strains isolated in a farm belonged to the same serogroup.

Biotypes. For biotyping studies, strains were selected to be representative of all the farms (Table 1). Simplified biotypes found in the 126 *E. coli* strains (from 119 different farms) which were tested are listed in Table 2. A total of 14 different biotypes were distinguished. They received code numbers according to the pattern of carbohydrate fermentation which characterized them, as described in Materials and Methods. Positive fermentation reactions were usually very strong and readable after 6 h of incubation for sucrose, rhamnose, and raffinose; after 24 h for sorbose; and after 24 or 48 h for sorbitol. The correlation between biotypes and O serogroups is shown in Table 3. Most serogroup O103 strains (68 of 72) fell into biotype 14 (sorbose and rhamnose negative; dulcitol, raffinose, and sucrose positive). Furthermore, 70 of 72 strains of serogroup O103 were rhamnose negative (biotype code below or equal to 14). The other most represented biotype was code 30 (all positive except sorbose). The last two O103 strains belonged to this biotype, which differs from biotype 14 only by the rhamnose reaction. Four more

TABLE 3. O serogroups and biotypes of 126 *E. coli* strains from weaned rabbits

Biotype	No. of strains in O serogroup							
	2	15	68	85	103	128	132	NI[a]
Rhamnose-negative strains								
6					1			
12					1			
13			4					
14					68			
Rhamnose-positive strains								
16								1
18				1				
19			1	1				
24								1
26								1
27	2							1
28	1							6
29								1
30	1	1	3		2	4	12	6
31	3		1					2

[a] NI, Rough strains or strains that were untypeable with available antisera.

TABLE 4. Pathogenic characteristics of 39 *E. coli* strains belonging to different serogroups and biotypes[a]

Strain	O serogroup	Biotype	No. of diseased animals/ no. of inoculated animals	
			Diarrhea[b]	Mortality[c]
C55	103	6	3/3	1/3
B10	103	14	2/3	2/3
C70	103	14	2/3	1/3
C148	103	14	1/2	1/2
C199	103	14	3/3	2/3
D23	103	14	1/3	1/3
D94	103	14	3/3	2/3
D112	103	14	3/3	2/3
D139	103	14	3/3	3/3
E1	103	14	3/3	3/3
E13	103	14	3/3	3/3
E22	103	14	3/3	3/3
E31	103	14	3/3	3/3
E37	103	14	3/3	3/3
E46	103	14	3/3	3/3
C124	103	30	2/3[d]	0/3
C127	103	30	0/3	0/3
C102	68	13	3/3	2/3
C110	68	13	3/3	3/3
C230	68	13	3/3	3/3
D145	68	13	2/3	1/3
B76	68	19	0/3	0/3
C142	68	30	0/3	0/3
D85	68	30	0/3	0/3
C121	68	31	0/3	0/3
D100	2	27	0/3	0/3
D121	2	27	1/3[d]	0/3
C178	2	28	0/3	0/3
C157	2	30	0/3	0/3
B72	2	31	0/3	0/3
D46	132	30	1/3[d]	0/3
D136	132	30	1/3[d]	0/3
E40	132	30	0/3	0/3
E70	132	30	0/3	0/3
E82	132	30	3/4[d]	1/4
C6	128	30	0/3	0/3
C104	128	30	1/3[d]	0/3
A155	85	18	0/3	0/3
D28	15	30	0/3	0/3

[a] Approximately $8 \cdot 10^9$ bacteria were inoculated by oral canula to groups of two to four weaned rabbits.

[b] Clinical signs included weight loss, dehydration, and profuse watery diarrhea with patent or occult blood in feces (exceptions are described in footnote *d*).

[c] Death occurred 5 to 14 days after inoculation and 2 to 12 days after the onset of diarrhea.

[d] Mild diarrhea with intestinal flood noise, no dehydration, and growth retardation without weight loss.

strains, all of the O68 group, also fell into rhamnose-negative biotypes (code 13).

Experimental infections. After experimental infection, a representative panel of 39 tested strains gave the results shown in Table 4. Two types of enteric diseases could easily be distinguished by clinical signs. The first was enteropathy with severe weight loss, profuse liquid diarrhea, and dehydration leading to the death of most of the animals within 5 to 14 days. Usually, patent or occult blood was demonstrated in the feces of these rabbits, and paintbrush hemorrhages of the cecal serosa could be seen. The strains inducing this type of enteropathy belonged to serogroup O103 or O68, and all fell into rhamnose-negative biotypes (code 6, 14, or 13). Globally, O103 rhamnose-negative strains induced scouring in 39 of 44 rabbits (88.6%) and caused the death of 33 of 44 rabbits (75%). Serogroup O68 rhamnose-negative strains gave the same results (diarrhea, 11 of 12 rabbits [91.7%]; mortality, 9 of 12 rabbits [75%]).

The cecal contents of dead animals always contained more than 10^9 *E. coli* cells, which could be demonstrated to belong to the same serogroup and biotype as the inoculated strain.

The second type of enteropathy which could be demonstrated was mild diarrhea without dehydration, intestinal flood noise, transient growth retardation, and no spontaneous mortality. Usually, these scours occurred 2 to 10 days after inoculation. As shown in Table 4, strains giving such enteropathy were from serogroups O103, O2, O132, and O128. All these strains were rhamnose positive, and most of them had a code of 30.

Strains producing no clinical signs after experimental inoculation (Table 4) all belonged to rhamnose-positive biotypes as well.

Therefore, among the isolates we tested there was a strong correlation between the rhamnose-negative character and the ability to induce severe life-threatening diarrhea (19 of 19), whereas only some rhamnose-positive strains (6 of 20) induced irregularly mild diarrhea without mortality. Thus, biotyping or even only rhamnose fermentation testing may be an interesting help in the quick diagnosis of highly rabbit-enteropathogenic strains.

Antibiotic susceptibility testing. No additional interesting information was obtained from antibiotic susceptibility testing of the 39 strains under study. All strains were susceptible to ampicillin, amoxicillin, gentamicin, colistin, and flumequine. All were resistant to erythromycin and spiramycin. Pathogenic strains from serogroups O103 and O68 fell, respectively, into eight and two different antibiotypes.

DISCUSSION

As stated by Okerman (9), routine laboratory diagnosis of *E. coli* rabbit-enteropathogenic strains is not an easy matter. Until now, mainly two pathogenic properties of enteropathogenic *E. coli* have received attention: in vivo or in vitro adhesion to cells and production of cytotoxins. However, routine testing for these properties is not within the reach of all diagnostic laboratories. Moreover, properties like adhesion to intestinal mucosa in vivo seem to be irregularly correlated with real enteropathogenicity, i.e., induction of diarrheic syndrome after experimental inoculation of the adherent strain (12). These observations led us to search for markers which might be simple enough to be used routinely and which might be correlated to enteropathogenicity as judged by Henle-Koch postulates (i.e., as stated by experimental infection of sensitive healthy weaned rabbits with subsequent appearance of clinical signs of diarrhea, weight loss, mortality, and reisolation of the inoculated strain).

The *E. coli* strains used in this study were all isolated from diarrheic animals. This does not mean all of them were the etiologic agents of the enteritis. *E. coli* is a species frequently found in rabbit gut at low rates, and ecological conditions associated with an enteritic syndrome may favor the proliferation of a saprophytic strain and its colonization of the gut. Although we have not shown here results obtained with additional strains from healthy rabbits, we assume that our strain panel is representative of strains present in French

rabbitries experiencing diarrhea problems. To our knowledge and in our experience, the markers described here for enteropathogenic strains are not found in strains isolated from healthy weaned young rabbits, although we have indirect evidence that they might be presented by strains carried without trouble by adult rabbits. We have shown, for instance, that some does had anti-serogroup O103 lipopolysaccharide antibodies of the immunoglobulin A class in their feces and milk (A. Milon and R. Camguilhem, submitted for publication). However, isolation of O103 strains could not be achieved in these does, suggesting that these antibodies were more the signs of a bygone contact than of actual carriage.

Our panel of French strains isolated from weaned diarrheic rabbits may be divided into three main groups: strains from group 1 produced severe enteritis after experimental inoculation of sensitive animals, which showed watery diarrhea, weight loss, and dehydration leading to death in most cases. Strains from group 2 induced only a mild diarrheic syndrome with transient growth retardation, whereas strains from group 3 induced no clinical signs at all.

Strains from group 1 are part of serogroup O103 or O68 and gave biotype codes including a rhamnose-negative reaction (O68, biotype code 13; O103, biotype code 6 or 14). In this group, serogroup O68 strains may be assigned to biotype 4 of the four biotypes described by Okerman and Devriese for rabbit-enteropathogenic strains (10). This biotype, which would have been coded 13 in our simplified scheme, was represented in their work by only one nontypeable strain (10). The serogroup O103 rhamnose-negative strains fit perfectly well with the biotype 8 recently described by Peeters et al., which consists of O103:K−:H2 strains (13). These researchers stressed that this biotype and the biotype 3 (O15:K−:H−, RDEC-1-like strains) previously described by Okerman and Devriese (10) represent the most highly pathogenic rabbit *E. coli* strains. In this respect, we must add the biotype 4 of Okerman and Devriese (10), which had not been detected by Peeters et al. in their strain panel. Based on our results, it seems that biotype 8 (O103, rhamnose-negative) strains are the most frequently encountered in French rabbitries with diarrhea problems during fattening. It is likely that isolates of this group diverged from an initial strain (16). However, no additional information was given by antibiotypes, which were heterogeneous. Since two O103 strains (C124 and C127; Table 4) were shown to be nonpathogenic or to induce only mild diarrhea without mortality, we assume that serogrouping alone is not sufficient to qualify these strains. However, since these last two strains were rhamnose positive, the combination of serogrouping and biotyping or even rhamnose fermentation testing seems sufficient to identify highly pathogenic strains of group 1 routinely.

The second group of strains is responsible for mild diarrheas with few or no weight losses and mortalities. These strains belong to serogroup O2, O128, O132, or O103. All of them are rhamnose positive (mainly of biotype code 30). Because of their serogroups, biotypes, and in vivo pathogenic properties, these strains fit fairly well with Okerman's biotype 2 (10), which has been defined by O109, O123, O128, O132, and nontypeable strains with biotypes which would have been coded as 28 or 30 in our scheme. Peeters et al. (13) stressed that biotype 2 is of limited diagnostic significance since (i) biotype 2 strains are irregularly endowed with attaching-effacing properties, (ii) they are frequently isolated from healthy rabbits, and (iii) they are mostly involved in moderate field diseases which may be easily treated with antibiotics and hygienic measures. Our experimental results are consistent with these findings.

All the strains of group 3, i.e., inducing no clinical signs after experimental inoculation, also fell into rhamnose-positive biotypes. Thus, highly pathogenic strains of group 1 seem to differ from those of both the other groups by rhamnose fermentation reactions. Although we do not know through which intimate mechanism this negative characteristic may be linked to pathogenicity, we think it is an interesting clue to quick diagnosis of highly enteropathogenic strains of biotypes 4 and 8 found in French rabbitries. This assumption may be extended to strains isolated in other countries of Western Europe. In their study of a series of 568 strains mainly from Belgium and Holland, Peeters et al. showed that the rhamnose-negative character is scarcely detected in strains isolated from rabbits (13). They found only two rhamnose-negative strains (so-called biotypes 5 and 18) outside the pathogenic biotypes 4 and 8 (13). Unfortunately, they did not further analyze the pathogenicity of these strains.

Okerman and Devriese also showed the occurrence of two other biotypes (biotypes 1 and 3) (10). Okerman's biotype 1 (10) *E. coli* strains were found to be associated with neonatal diarrhea in rabbits under 2 weeks of age. These strains were occasionally isolated from weaned rabbits but did not produce any clinical signs when experimentally inoculated to such animals (6, 10, 14). These strains were of the O109:H2 serotype, with a biotype which would have been coded as 28 in our scheme. We found 7 strains of 126 with this biotype character (Table 3). One was serogroup O2; the other one could not be grouped. Since anti-O109 antiserum was not used in our serogrouping scheme, it is possible that these strains belong to this group of neonatal strains. Okerman's biotype 3 (10) included highly pathogenic RDEC-1-like strains, as described by Cantey and Blake (5). They are characterized by O15 antigen and lack of motility and flagellar antigen. They are rhamnose positive and would have fallen into code 31 in our work. We found only 6 of 126 strains of this biotype. Three were O2, one was O68, and two could not be typed; but none belonged to group O15, and all were motile. Two of these strains were checked for pathogenicity in weaned rabbits, and neither gave any clinical signs (Table 4, strains C121 and B72). The only O15 isolate we found (strain D28, Table 4) had a code of 30 and was also found to be nonpathogenic. We must conclude here that RDEC-1-like strains are not of epidemiologic importance in French weaned rabbits, since no strains of this type could be isolated from 119 farms with diarrhea problems. On the contrary, most of our isolates seemed to be part of the O103 rhamnose-negative group, which is scarcely detected in Belgium or Holland as judged by the literature (9, 10, 12–14). Nevertheless, it seems that enteropathogenic *E. coli* strains isolated from weaned rabbits in Western Europe show a clear-cut geographical, epidemiologically meaningful distribution.

Work is under way in our laboratory to identify the main mechanisms involved in the pathogenicity of serogroup O103 rhamnose-negative strains. One of us (R.C.) has already shown that after experimental inoculation of one of these strains (strain B10; Table 4) the bacteria could be seen to adhere to the apex of epithelial cells of intestinal vili, as judged by histological examination (3). We also have preliminary evidence that all O103 rhamnose-negative strains tested here for experimental pathogenicity adhered in vitro to rabbit intestinal vili, whereas both O103 rhamnose-positive ones did not. However, adhesion to intestinal mucosa has not been demonstrated to be strictly correlated to enteropathogenicity in rabbits (12).

To conclude, in this work (i) rabbit-enteropathogenic strains of *E. coli* isolated in France and causing experimentally severe diarrheas with high mortality rates are part of serogroup O103 or O68, mostly O103; (ii) O103 pathogenic strains mostly belong to biotype 8, as described by Peeters et al. (13), or to sucrose-negative variants of this biotype; these biotypes (code 6 or 14) are characterized by a rhamnose-negative reaction; (iii) since O68, biotype 4, pathogenic strains are also rhamnose negative, while all other tested strains (found to be nonpathogenic or to induce only mild diarrheas) are rhamnose positive, we think that the latter property may be important as a clue to the rapid diagnosis of highly enteropathogenic strains found in France, as well as for field prognosis and treatment. Furthermore, a simple combination of serogrouping and biotyping may be sufficient to identify all strains with high pathogenicity for weaned rabbits, i.e. to detect biotypes 3, 4, and 8: O15 agglutination and rhamnose semisolid medium to test both motility and rhamnose fermentation reaction. In such a combination, biotype 3 is identified by an O15-positive reaction, a rhamnose-positive reaction, and lack of motility; and biotypes 4 and 8 and related rhamnose-negative strains (such as sucrose-negative pathogenic variants [O103, biotype code 6]) are identified by their rhamnose-negative character.

LITERATURE CITED

1. **Bauer, A. W., W. M. M. Kirby, J. C. Sherris, and M. Turk.** 1966. Antibiotic susceptibility testing by a standardized single disc method. Am. J. Clin. Pathol. **45**:493–496.
2. **Camguilhem, R.** 1985. Isolement d'une souche d'*Escherichia coli* (sérogroupe O103) responsable d'entérite colibacillaire du lapin en engraissement. Rev. Med. Vet. (Toulouse) **136**:61–68.
3. **Camguilhem, R., F. Lebas, and C. Labie.** 1986. Reproduction expérimentale chez le lapin en engraissement d'une diarrhée provoquée par une souche d'*Escherichia coli* de sérogroupe O103. Ann. Rech. Vet. **17**:409–424.
4. **Camguilhem, R., G. Mureau, J. A. Nicolas, J. Brocas, and J. Tournut.** 1986. Groupage sérologique O et antibiosensibilité des souches d'*Escherichia coli* isolées en France sur les lapins diarrhéiques après le sevrage. Rev. Med. Vet. (Toulouse) **137**: 205–212.
5. **Cantey, J. R., and R. K. Blake.** 1977. Diarrhoea due to *Escherichia coli* in the rabbit, a novel mechanism. J. Infect. Dis. **135**:454–462.
6. **Coussement, W., R. Ducatelle, G. Charlier, L. Okerman, and J. Hoorens.** 1984. Pathology of experimental colibacillosis in rabbits. Zentralbl. Veterinaermed. Reihe B **31**:64–72.
7. **Gouet, P., and G. Fonty.** 1979. Changes in the digestive microflora of holoxenic rabbits from birth until adulthood. Ann. Biol. Anim. Biochim. Biophys. **19**:553–566.
8. **Licois, D., P. Coudert, J. F. Guillot, and L. Renault.** 1982. Diarrhées expérimentales du lapin: étude de la pathologie due à des coccidioses intestinales (*E. intestinalis*) et à des *Escherichia coli*. 3èmes Journées de la Recherche Cunicole INRA-ITAVI. Publ. Comm. no. 27. ITAVI, Paris.
9. **Okerman, L.** 1987. Enteric infections caused by non enterotoxigenic *Escherichia coli* in animals: occurrence and pathogenicity mechanisms. A review. Vet. Microbiol. **14**:33–46.
10. **Okerman, L., and L. A. Devriese.** 1985. Biotypes of enteropathogenic *Escherichia coli* strains from rabbits. J. Clin. Microbiol. **22**:955–958.
11. **Ørskov, F., and I. Ørskov.** 1984. Serotyping of *E. coli*, p. 43–112. *In* T. Berman (ed.), Methods in microbiology, vol. 14. Academic Press, Inc. (London), Ltd., London.
12. **Peeters, J. E., P. Dussart, and R. Geeroms.** 1986. Diagnostic de la colibacillose (EPEC) chez le lapin: correlation entre les observations histologiques, la numération semi-quantitative et le biotypage. 4èmes Journées de la Recherche Cunicole INRA-ITAVI. Publ. Comm. no. 33. ITAVI, Paris.
13. **Peeters, J. E., R. Geeroms, and F. Ørskov.** 1988. Biotype, serotype, and pathogenicity of attaching and effacing enteropathogenic *Escherichia coli* strains isolated from diarrheic commercial rabbits. Infect. Immun. **56**:1442–1448.
14. **Peeters, J. E., P. Pohl, L. Okerman, and L. A. Devriese.** 1984. Pathogenic properties of *Escherichia coli* strains isolated from diarrheic commercial rabbits. J. Clin. Microbiol. **20**:34–39.
15. **Renault, L., J. Roux, E. Lebourhis, P. Coudert, D. Licois, and F. Guillot.** 1983. Description d'un sérogroupe (O103) d'*Escherichia coli* entéropathogène chez le lapin au sevrage. Bull. Acad. Vet. Fr. **56**:387–400.
16. **Stenderup, J., and F. Ørskov.** 1983. The clonal nature of enteropathogenic *Escherichia coli* strains. J. Infect. Dis. **148**: 1019–1024.
17. **Varga, J., and L. Pesti.** 1982. Serological and some pathological characteristics of *Escherichia coli* strains isolated from rabbits. Zentralbl. Veterinaermed. Reihe B **29**:145–152.