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ORIGINAL ARTICLE

Antimicrobial resistance in *Campylobacter coli* and *Campylobacter jejuni* in cynomolgus monkeys (*Macaca fascicularis*) and eradication regimens[☆]



Tetsufumi Koga^{a,*}, Wataru Aoki^b, Takashi Mizuno^b,
Kuniko Wakazono^b, Junki Ohno^b, Tsunehiro Nakai^b,
Takao Nomiya^b, Miki Fujii^b, Keiichi Fusegawa^a,
Kazuya Kinoshita^a, Takakazu Hamada^a, Yoshinori Ikeda^b

^a Biological Research Laboratories, Daiichi Sankyo Co., Ltd., Tokyo, Japan

^b KAC Co., Ltd., Tokyo, Japan

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Background: *Campylobacter* spp. are zoonotic pathogens, however, knowledge about their presence and antimicrobial resistance in nonhuman primates is limited. Our animal facility purchased cynomolgus monkeys (*Macaca fascicularis*) from various Asian countries: China, Cambodia, Indonesia, the Philippines, and Vietnam.

Methods: Colonization by *Campylobacter* spp. was investigated in 238 of the monkeys from 2009 to 2012 and antimicrobial susceptibility testing was carried out for these isolates. Furthermore, we eradicated these pathogens from these monkeys.

Results: *Campylobacter* spp. were isolated from 47 monkeys from three specific countries: China, Cambodia, and Indonesia, with respective isolation rates of 15%, 36%, and 67%. Two monkeys, which were each infected with *Campylobacter jejuni* and *Campylobacter coli*, showed clinical symptoms of diarrhea and bloody feces. In total, 41 isolates of *C. coli* and 17 isolates of *C. jejuni* were detected. Antimicrobial susceptibility varied: in the monkeys from China, erythromycin (ERY)-, tetracycline (TET)-, and ciprofloxacin-resistant *C. coli*, in the monkeys from Cambodia, amoxicillin-intermediate, TET- and ciprofloxacin-resistant *C. coli* and amoxicillin- and ciprofloxacin-resistant *C. jejuni*, and in the monkeys from Indonesia,

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* Corresponding author. Biological Research Laboratories, Daiichi Sankyo Co., Ltd., 2-58 Hiromachi 1-chome, Shinagawa-ku, Tokyo 140-8710, Japan.

E-mail address: koga.tetsufumi.zj@daiichisankyo.co.jp (T. Koga).

ciprofloxacin-resistant *C. coli* and TET- and ciprofloxacin-resistant *C. jejuni* were common (>75%). Multiresistant isolates of *C. coli* were found in monkeys from all countries and multiresistant isolates of *C. jejuni* were found in monkeys from Indonesia. The eradication rate with azithromycin was comparable to that with gentamicin (GEN) by oral administration, and was higher than those with amoxicillin-clavulanic acid (AMC) and chloramphenicol (CHL).

Conclusion: From the perspective of zoonosis, we should acknowledge multiresistant *Campylobacter* spp. isolated from the monkeys as a serious warning.

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Introduction

Animals kept in captivity or bred in semi-free-range outdoor areas may become infected with enteropathogens in their enclosures.¹ *Campylobacteriosis* is an important zoonosis throughout the world.² Thermophilic *Campylobacter* spp. have been isolated from the intestinal tracts of a wide variety of animals, including poultry, swine, and captive and free-range wild animals.^{3–6} *Campylobacter* spp., particularly *Campylobacter jejuni* and *Campylobacter coli*, are recognized as one of the most frequent causes of acute diarrheal disease in humans.⁷

In recent years, concern about this pathogen has increased mainly because of the frequent isolation of antimicrobial-resistant isolates in humans and animals⁸ in both developed and developing countries, particularly with regard to the rapid emergence of fluoroquinolone-resistant and multidrug-resistant *Campylobacter* spp. Antimicrobial resistance in both medicine and agriculture is recognized by the World Health Organization (WHO), along with other various national authorities, as a major emerging public health concern. It represents a significant challenge of global dimensions to human and veterinary medicines with the prospect of therapeutic failure for life-saving treatments now a reality.

When cynomolgus monkeys (*Macaca fascicularis*) were introduced to our animal facility, or were checked during semi-annual health monitoring, or when abnormal gastrointestinal symptoms such as diarrhea and loose stool occurred, we checked the monkeys for the presence of *Campylobacter* spp. from 2009 to 2012 and eradicated them for the following reason: some research showed that *Campylobacter* spp. were linked to gastroenteritis in nonhuman primates.^{9–11} Infected monkeys are potential reservoirs if they are asymptomatic, and they become potential transmitters of *Campylobacter* spp. to noninfected monkeys and humans who have had contact with them.¹² Moreover, infected monkeys might jeopardize the interpretation of experimental results.¹³

This study was conducted to determine the prevalence and the antimicrobial resistance of *Campylobacter* spp. and to eradicate them from cynomolgus monkeys.

Material and methods

Sample collection

Two hundred and thirty-eight cynomolgus monkeys were used in this study (Table 1). These monkeys were bred in a

Table 1 Prevalence of *Campylobacter* spp. in monkeys from different countries of origin

Country (place)	No. of monkeys		<i>Campylobacter</i> spp. positive no. of monkeys		No. of <i>Campylobacter</i> spp.		Prevalence rate (%)
	Male	Female	Male	Female	<i>C. coli</i>	<i>C. jejuni</i>	
China (Pingnan)	53	29	5	7	10	2	15
China (Hainan)	6	0	0	0	0	0	0
China (Guangxi)	5	0	0	0	0	0	0
China (unknown)	21	5	0	0	0	0	0
Cambodia (Kampong Thom) ^a	36	0	13	0	9	6	36
Indonesia (Uma Uma Island) ^b	0	33	0	22	22	9	67
Indonesia (others)	29	1	0	0	0	0	0
Philippines	1	5	0	0	0	0	0
Vietnam	11	2	0	0	0	0	0
Others	1	0	0	0	0	0	0
Total	163	75	18	29	41	17	0

^a Prevalence rates of monkeys from Cambodia were significantly higher than those from China (Pingnan).

^b Prevalence rates of monkeys from Indonesia were significantly higher than those from China (Pingnan) and Cambodia.

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