

## Serum DDT in malaria vector control sprayers in Mato Grosso State, Brazil

DDT em soro sangüíneo de agentes de saúde da Fundação Nacional de Saúde no Estado de Mato Grosso, Brasil

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**Abstract** DDT was used intensively in vector control programs in Mato Grosso State until 1997. The present study aimed to determine DDT concentrations in blood samples from Brazilian National Health Foundation workers in Mato Grosso. Blood samples were analyzed from 41 sprayers, 20 drivers, and 14 unexposed workers, collected in June 1999 and October 2000 in two regions of the State (Sinop and Cáceres). Sprayers and drivers were occupationally exposed, and no significant differences were found in serum DDT levels between these two groups in either region. Likewise, no significant differences were found in p,p'DDE and total DDT levels between Cáceres and Sinop. However, p,p'DDT levels were higher in Sinop due to the intensive use of this insecticide in the region in recent years. The two regions together showed the following results: total DDT ranging from 7.50µg/L to 875.5µg/L (median = 135.5µg/L) for sprayers; from 34.5µg/L to 562.3µg/L (median = 147.7µg/L) for drivers; and from undetected to 94.8µg/L (median = 22.5µg/L) for unexposed workers.

**Key words** Insecticides; DDT; Occupational Exposure; Occupational Health

**Resumo** O uso de DDT em campanhas de saúde pública foi intenso em Mato Grosso, tendo sido suspenso em 1997. Este estudo objetivou determinar os níveis de DDT em amostras de sangue de funcionários da Fundação Nacional de Saúde de Mato Grosso. Foram analisadas 41 amostras de soro sangüíneo de agentes de saúde, 20 de motoristas e 14 de trabalhadores não expostos coletadas em julho de 1999 e outubro de 2000 em duas regiões do Estado (Sinop e Cáceres). Os agentes de saúde e os motoristas estiveram ocupacionalmente expostos, não havendo diferença significativa entre os resultados destes dois grupos nas duas regiões. Não foram encontradas diferenças significativas nos teores de p,p'DDE e DDT total entre os resultados das duas regiões, entretanto, os níveis de p,p'DDT foram significativamente maiores no Distrito de Sinop devido ao fato do DDT ter sido mais intensamente usado neste distrito em anos mais recentes. Os níveis de DDT total variaram de 7,50µg/L a 875,5µg/L (mediana = 135,5µg/L) para os agentes de saúde; de 34,5µg/L a 562,3µg/L (mediana = 147,7µg/L) para os motoristas e de não detectado a 94,8µg/L (mediana = 22,5µg/L) para os trabalhadores não expostos.

**Palavras-chave** Inseticidas; DDT; Exposição Ocupacional; Saúde Ocupacional

## Introduction

Mato Grosso State in Central Western Brazil is an endemic area for malaria. According to the Mato Grosso State Office of the Brazilian National Health Foundation (FUNASA/MT), DDT was used for malaria vector control until 1997, when its use was banned by a court decision.

Malaria occupies a prominent place among the tropical endemic diseases. Brazil, Peru, Guyana, and 18 other malaria-endemic countries of the Americas presented a consistent pattern of low rates of malaria until the late 1970s, followed by a geometric increase in malaria incidence in subsequent years. According to Roberts et al. (2000), true growth in malaria incidence corresponds temporally to changes in global strategies for malaria control. Underlying the concordance of these events is a causal link between decreased spraying of dwellings with DDT and increased malaria. Separate analyses of data from 1993 to 1995 showed that countries that have recently discontinued their spraying programs are reporting major increases in malaria incidence. The history of the struggle against malaria in Brazil is over 50 years old, and the most frequently used strategy has been spraying of domiciles with DDT (Souza, 1998).

Although DDT brought undeniable benefits to public vector control campaigns, its use was banned due to its eco-toxicological risks as a consequence of its persistence in the environment, bioaccumulation in food chains, and slow elimination from living beings.

Workers involved with domiciliary DDT spraying as part of vector control campaigns are particularly vulnerable to contamination by this substance due to their high exposure. Souza (1998) conducted a survey on the use of insecticides by FUNASA/MT sprayers and called attention to their lack of training and preparation for handling such compounds. The author also reported that even when personal protective equipment was available, workers resisted using it, claiming that it was uncomfortable and interfered with their work. The same situation is common among agricultural workers in developing countries, where pesticides tend to be handled carelessly, and personal protective equipment is seldom used (Jeyaratnam, 1993).

Organochlorine pesticide residues have been detected in the blood serum of exposed and unexposed workers around the world. Several studies on the contamination of personnel working in vector control household spraying have been conducted in Brazil.

In the State of Minas Gerais, Franklin & Peixoto (1986) studied 106 sprayers from SU-CAM (the Superintendency of Public Health Campaigns) who handled HCH (hexachlorocyclohexane, 30% gamma-isomer), widely utilized to control Chagas disease vectors, to determine the serum levels of this insecticide. A control group of unexposed individuals was also analyzed. Blood samples from 10 unexposed individuals were collected and analyzed.  $\beta$ -HCH was detected in all samples at levels varying from 0.08 to 0.68  $\mu\text{g}/\text{dL}$ , while  $\alpha$ -HCH was detected in only three samples. Among the exposed workers, only  $\beta$ -HCH was detected in all samples, at concentrations from 0.19 to 13.44  $\mu\text{g}/\text{dL}$ . This can be explained by the fact that this is the most stable and persistent isomer. No correlation was found between time on the job as sprayers and HCH blood levels.

Carvalho & Berbet (1987) measured serum organochlorine insecticides (DDT and HCH) in occupationally exposed vector control workers in the State of Bahia. They reported high absorption levels, exceeding the limits established by occupational health legislation. This excessive absorption occurred partially due to the lack of use of personal protective equipment, workers' habits in the work environment, and lack of knowledge concerning proper handling measures and techniques for pesticide application. Mean serum concentration in a control group was  $3.23 \pm 2.72 \mu\text{g}/\text{L}$  for total HCH and  $8.55 \pm 9.14 \mu\text{g}/\text{L}$  for total DDT. In this group, o,p'-DDT and p,p'-DDD were not detected and p,p'-DDT was found in only three samples, while p,p'-DDE appeared in all samples, with a mean concentration of  $8.32 \pm 9.03 \mu\text{g}/\text{L}$ . Among the three exposed groups that were studied (one group with recent but not past exposure to DDT, one with past but not recent exposure, and one with both past and recent exposure), the latter showed the highest mean serum concentration, with  $732.50 \pm 685.20 \mu\text{g}/\text{L}$ . From the occupational health point of view, all exposed groups presented total serum DDT levels above the values considered normal in NR-7 (see below), that is, 30  $\mu\text{g}/\text{L}$ .

Act 6,514 (Dec. 22, 1977) of the Brazilian Ministry of Labor, in its Regulatory Provision NR-7, established threshold limit values (TLVs) for chemicals in biological samples from workers. TLVs are the maximum tolerable concentrations of endogenous substances not to be exceeded in the human body. For serum DDT, the TLV was set at 500  $\mu\text{g}/\text{L}$ . According to this same legislation, normal serum DDT concentration in individuals without occupational exposure to this chemical was 30  $\mu\text{g}/\text{L}$ . These guide-

lines were re-edited in 1994, when organochlorine pesticides were excluded.

Minelli & Ribeiro (1996a) determined serum insecticide residues in 26 sprayers who had handled HCH and DDT in malaria vector control campaigns in São José do Rio Preto, São Paulo State. The control group of unexposed workers consisted of 16 individuals. The substances o,p'-DDT and  $\gamma$ -HCH were detected in 62% and 92% of the samples, respectively. All blood samples were contaminated with  $\alpha$ -HCH,  $\beta$ -HCH, p,p'-DDT, and p,p'-DDE at mean concentrations of 0.4, 31.8, 64.3, and 13.5  $\mu\text{g/L}$ , respectively. The levels of  $\beta$ -HCH, p,p'-DDE, and p,p'-DDT were considerably higher than those found in samples of unexposed workers, with mean concentrations of 3.3, 14.3, and 1.5  $\mu\text{g/L}$ , respectively.

Recent studies of groups not occupationally exposed to organochlorine pesticides were conducted in Brazil by Koifman et al. (1998), Paumgarten et al. (1998), and Delgado et al. (2002). The first group performed a case study to investigate the occurrence of a cancer cluster among young indigenous adults in an Amazonian village. The authors evaluated the different environmental exposures possibly associated with this cancer cluster, i.e., exposure to ionizing radiation, organochlorine (DDT) and organophosphorus pesticides, and heavy metals. 89 blood samples were analyzed, and median serum p,p'-DDT ranged from 26.3  $\mu\text{g/L}$  (men 30 years of age or older) to 58.1  $\mu\text{g/L}$  (children).

Serum organochlorine pesticide levels were determined in agricultural workers from Rio de Janeiro State by Paumgarten et al. (1998). p,p'-DDE was detected in 16 of 26 samples, but p,p'-DDE exceeded the limit of quantification of 1.4  $\mu\text{g/L}$  in only three samples.

Delgado et al. (2002) analyzed organochlorine pesticides in blood samples from 33 volunteers who had been living in Greater Metropolitan Rio de Janeiro for at least 5 years. p,p'-DDE was found in 17 of the 33 samples at levels varying from 1.4 to 4.8  $\mu\text{g/L}$ .

Organochlorines are known to be toxic to the central and peripheral nervous systems, causing hypersensitivity in nerves and muscles (WHO, 1979).

There is still controversy over the adverse effects of chronic exposure to DDT. However, it has been proven that DDT causes hepatic alterations in various rodent species and that these changes can progress to tumor formation in some species (WHO, 1979).

Although several studies have attempted to correlate DDT exposure and cancer in humans, none has obtained unequivocal confirmation

of this correlation (Albert, 1981; Cantor & Booze, 1991; Falck et al., 1992; Olaya-Contreras et al., 1998; Romieu et al., 2000; Wassermann et al., 1979). Another more recent concern is the potential of DDT and its metabolites to interact with the endocrine system (McLachlan & Arnold, 1996). The effects of these substances on reproduction in birds and alligators have already been shown. Snedeker (2001) reviewed studies which attempted to correlate pesticides (DDT, DDE, and dieldrin) with breast cancer risk. According to the author, several early descriptive studies and a cohort study identified a positive association between breast cancer risk and adipose or blood levels of these pesticides. Most of the nested case-control and case-control studies conducted since 1996 failed to confirm these early observations, while two studies conducted in Colombia and Mexico found an increased risk of breast cancer in women with high DDE levels.

Malaria incidence was high in the northern region of Mato Grosso State, along the southern border of the Amazon Forest, where high amounts of DDT may have been used. The Brazilian National Health Foundation divides the State into four districts for administrative purposes (Figure 1). The District of Sinop, located in the North of Mato Grosso, and that of Cáceres, in the Southwest of the State, were selected for this study, aimed at obtaining data on contamination levels in National Health Foundation (FUNASA) personnel involved in household DDT spraying.

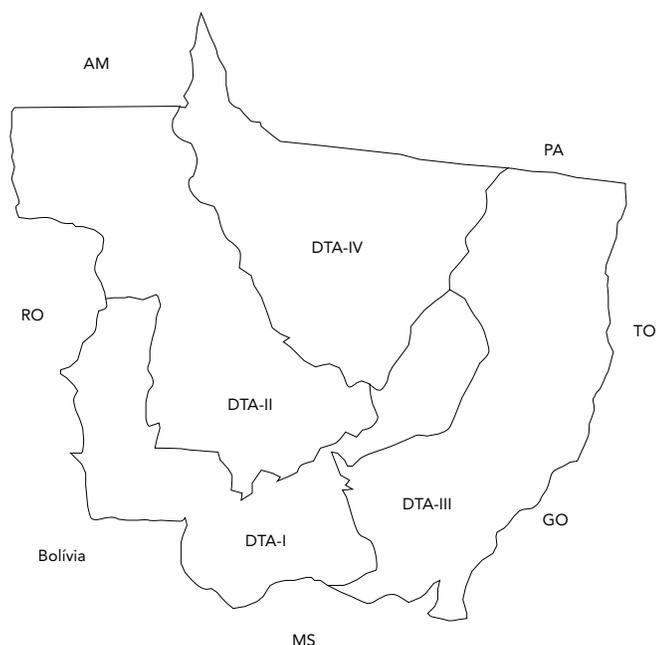
## Methods

The District of Sinop, in the North of Mato Grosso, includes 30 municipalities (or counties). The main economic activities are lumbering, cattle-raising, and gold-mining. The FUNASA staff in Sinop consisted of 144 sprayers (also referred to as health agents), 15 drivers, and 15 office workers. In the District of Cáceres, in the Southwest of Mato Grosso, with 29 municipalities, there were 74 sprayers, 13 drivers, and 8 office workers at the time of the study.

Since there were no previous data on serum DDT levels in Mato Grosso, the sample size was calculated based on data from the study carried out by Minelli & Ribeiro (1996a) with sprayers in São José do Rio Preto, São Paulo. In addition to the sprayers, drivers were also considered to be exposed to DDT, since they were responsible for loading and unloading the insecticide in the vehicles, besides accompany-

Figure 1

Administrative districts of Mato Grosso State (FUNASA/MT), Brazil.



DTA I – District of Cáceres  
 DTA II – District of Nortelândia  
 DTA III – District of Rondonópolis  
 DTA IV – District of Sinop



ing the house spraying. Office workers were classified as unexposed.

The samples collected and analyzed in June 1999 in Sinop consisted of 23 sprayers, 12 drivers, and 7 office workers, and those collected in October 2000 in Cáceres included 18 sprayers, 8 drivers, and 7 office workers. Blood sample donors were randomly chosen from the staff list furnished by FUNASA/MT, and participation in the study was voluntary. After explaining the study's objectives and procedures, the randomly chosen volunteers were asked to sign an informed consent form.

All participants were asked questions on their work history. 10mL blood samples were then taken from an arm vein using disposable needles and syringes and transferred to test tubes. After clotting, serum was separated by

centrifugation, transferred to a Teflon stoppered sample vial and kept under ice for transportation to the laboratory of the Federal University of Mato Grosso, where the samples were immediately frozen.

DDT residues were analyzed using the method previously described by Minelli & Ribeiro (1996b), which consists of pesticide extraction from a serum-silica suspension with n-hexane-acetone (9:1), extract purification using alumina column chromatography, and analysis of the final extract using gas-liquid chromatography with electron capture detection ( $^{63}\text{Ni}$ ). All solvents were residue grade, and reference standards were 98-99% pure, purchased from Supelco. Standard solutions were prepared in isooctane. All samples were analyzed in duplicate, and the results were presented as a mean of the two results. Chromatographic parameters were as follows: carrier gas: high purity nitrogen; gas flow: 30mL/min; oven temperature: 200°C; injector temperature: 235°C; detector temperature: 300°C; glass column (1,8m x 2mm i.d.) packed with 1.5% OV-17 + 1,95% QF-1 on 80-100 mesh Chromosorb WAW DMCS. Limits for residue quantification were determined as: p,p'DDT = 7.5 µg/L and p,p'DDE = 5 µg/L.

## Results and discussion

Serum p,p'DDE, p,p'DDT, and total DDT concentrations as well as the age, work duration, and jobs of volunteers from the District of Sinop are shown in Table 1. p,p'DDE was detected in 98% of the samples, while p,p'DDT was found in 85.7% (36 samples). Dechlorination of p,p'DDT in the human body results in p,p'DDE, which is more persistent than the parent compound, and DDE expressed as a percentage of total DDT increases after DDT intake decreases (WHO, 1979). Sprayers and drivers had not been exposed to DDT since 1997, which explains the fact that p,p'DDE levels were much higher than those of p,p'DDT in almost all of the samples.

Study subject number 38 presented pesticide concentrations much higher than the other unexposed workers, because he also worked as a storekeeper, where he handled DDT. This result was thus excluded from the unexposed sub-sample for statistical calculations.

Table 2 shows the serum p,p'DDE, p,p'DDT, and total DDT concentrations, age, work duration, and jobs of blood sample donors from the District of Cáceres. Similar to the results in Sinop, p,p'DDE was detected in all samples,

Table 1

Sex, job, work duration, age, and serum p,p'DDE, p,p'DDT, and total DDT in National Health Foundation (FUNASA) workers, District of Sinop, Mato Grosso State, Brazil, in June 1999.

Sample number	Sex	Job	Work duration (years)	Age (years)	Serum levels (µg/L)		
					p,p'DDE	p,p'DDT	Total DDT
S-1	M	Sprayer	12	35	35.5	ND	35.5
S-2	M	Sprayer	12	40	116.3	26.3	142.5
S-3	M	Sprayer	12	34	57.5	14.8	72.3
S-4	M	Sprayer	11	32	229.0	450	269.0
S-5	M	Sprayer	14	36	100.8	9.3	111.5
S-6	M	Sprayer	12	37	123.3	23.3	146.3
S-7	M	Sprayer	11	32	34.0	18.5	52.5
S-8	M	Sprayer	25	43	58.8	24.8	83.5
S-9	M	Sprayer	11	38	105.8	82.0	187.8
S-10	M	Sprayer	17	38	33.8	18.8	52.5
S-11	M	Sprayer	12	31	84.8	17.5	102.3
S-12	M	Sprayer	12	40	85.5	32.5	118.0
S-13	M	Sprayer	12	32	88.3	35.8	124.0
S-14	M	Sprayer	16	40	101.8	64.5	162.3
S-15	M	Sprayer	12	32	211.3	41.5	252.8
S-16	M	Sprayer	16	39	288.5	40.3	328.8
S-17	M	Sprayer	12	36	149.8	155.3	318.4
S-18	M	Sprayer	13	33	122.5	155.3	277.7
S-19	M	Sprayer	17	42	419.5	194.3	613.0
S-20	M	Sprayer	11	NC	212.8	177.8	390.3
S-21	M	Sprayer	14	41	115.3	30.5	145.8
S-22	M	Sprayer	17	NC	276.3	87.3	363.5
S-23	M	Sprayer	12	NC	399.5	476.0	875.5
S-24	M	Driver	37	NC	221.5	204.8	426.3
S-25	M	Driver	11	31	106.8	68.0	174.8
S-26	M	Driver	12	34	41.3	ND	41.3
S-27	M	Driver	12	42	374.0	188.3	562.3
S-28	M	Driver	16	54	98.0	25.5	123.5
S-29	M	Driver	16	54	303.5	131.3	436.3
S-30	M	Driver	12	38	86.3	64.0	150.3
S-31	M	Driver	12	52	189.3	11.0	198.8
S-32	M	Driver	13	38	72.5	28.0	100.6
S-33	M	Driver	12	34	89.8	137.5	227.3
S-34	M	Driver	13	50	150.0	77.3	227.1
S-35	M	Driver	16	48	82.5	ND	82.5
S-36	F	Sanitation agent	9	NC	ND	ND	< 5
S-37	M	Microscopist	11	37	24.0	23.0	47.0
S-38	M	Storekeeper	14	41	387.3	253.0	638.8
S-39	F	Office worker	13	35	14.7	ND	14.7
S-40	M	Statistician	12	35	7.3	ND	7.3
S-41	F	Office worker	11	38	21.8	10.3	32.0
S-42	F	Office worker	13	NC	10.5	12.0	22.5

ND = not detected; NC = data not collected.

Table 2

Sex, job, work duration, age, and serum p,p'DDE, p,p'DDT, and total DDT in National Health Foundation (FUNASA) workers, District of Cáceres, Mato Grosso State, Brazil, in October, 2000.

Number	Sex	Job	Work duration (years)	Age (years)	Serum levels (µg/L)		
					p,p'DDE	p,p'DDT	Total DDT
C-1	M	Sprayer	20	42	125.0	182.5	307.5
C-2	M	Sprayer	22	44	107.5	23.0	130.5
C-3	M	Sprayer	18	37	76.5	15.0	91.5
C-4	M	Sprayer	28	48	50.0	n.d.1	50.0
C-5	M	Sprayer	18	55	131.5	22.5	154.0
C-6	M	Sprayer	26	61	36.0	ND	36.0
C-7	M	Sprayer	28	NC	110.3	209.3	319.6
C-8	M	Sprayer	NC	48	100.5	11.5	112.0
C-9	M	Sprayer	17	42	135.5	ND	135.5
C-10	M	Sprayer	25	58	170.5	143.5	314.0
C-11	M	Sprayer	NC	42	7.5	ND	7.5
C-12	M	Sprayer	17	40	19.3	86.0	105.3
C-13	M	Sprayer	26	51	48.5	ND	48.5
C-14	M	Sprayer	27	58	68.5	20.5	89.0
C-15	M	Sprayer	13	33	216.8	19.3	236.1
C-16	M	Sprayer	24	48	101.0	ND	101.0
C-17	M	Sprayer	22	46	518.5	17.8	536.3
C-18	M	Sprayer	30	53	107.3	ND	107.3
C-19	M	Driver	NC	51	145.0	23.0	168.0
C-20	M	Driver	13	37	133.5	11.5	145.0
C-21	M	Driver	NC	52	34.5	ND	34.5
C-22	M	Driver	21	51	295.0	56.8	351.8
C-23	M	Driver	13	46	122.5	ND	122.5
C-24	M	Driver	18	52	98.5	ND	98.5
C-25	M	Driver	26	51	72.8	ND	72.8
C-26	M	Driver	24	53	75.8	ND	75.8
C-27	M	Office worker	15	47	14.5	ND	14.5
C-28	F	Office worker	20	41	39.0	ND	39.0
C-29	F	Office worker	23	48	94.8	ND	94.8
C-30	F	Office worker	23	58	8.0	10.0	18.0
C-31	F	Office worker	16	35	53.5	12.3	65.8
C-32	M	Office worker	NC	60	29.0	ND	29.0
C-33	M	Office worker	23	43	6.0	ND	6.0

ND = not detected; NC = data not collected.

while p,p'DDT was found in only 16 samples (48%).

According to the Kolmogorov-Smirnoff normality test, these results are not statistically normal. The descriptive statistical data for p,p'DDE, p,p'DDT, and total DDT levels are presented in Table 3, for sprayers, drivers, and unexposed workers. The comparison of these concentrations for exposed individuals (sprayers and drivers) and unexposed workers in the District of Sinop using the Mann-Whitney non-parametric variance analysis showed that there is a significant difference ( $p < 0.05$ ) between

the two risk groups studied (exposed versus unexposed), while the comparison of sprayers and drivers showed no significant difference ( $p > 0.05$ ). This indicates that despite their job differences, sprayers and drivers had been equally exposed. The same trend was observed in the District of Cáceres.

No correlations were found between serum pesticide levels and age or work duration in the study volunteers in either of the two districts.

Comparison of the results of p,p'DDE and total DDT between the two districts in exposed workers showed no significant difference

Table 3

Descriptive statistical data on serum p,p'DDE; p,p'DDT, and total DDT levels in National Health Foundation (FUNASA) workers in the Districts of Sinop and Cáceres, Mato Grosso State, Brazil.

District	Workers	Insecticide	N	Concentration (µg/L)			Q1	Q3
				Median	Maximum	Minimum	25th percentile	75th percentile
Sinop	Sprayers	p,p'DDE	23	115.8	419.5	35.5	84.8	212.8
		p,p'DDT		35.8	476.0	ND	18.8	87.3
		Total DDT		146.3	875.5	35.5	102.3	318.4
	Drivers	p,p'DDE	12	102.4	374.0	41.3	83.5	213.5
		p,p'DDT		66.0	204.8	ND	14.6	136.0
		Total DDT		186.6	562.3	41.3	106.3	376.5
	Un-exposed	p,p'DDE	6	12.6	24.0	ND	7.3	21.8
		p,p'DDT		5.2	23.0	ND	ND	12.0
		Total DDT		18.6	47.0	ND	7.3	32.0
Cáceres	Sprayers	pp'DDE	18	104.15	518.5	7.5	50.0	131.5
		pp'DDT		16.4	209.3	ND	ND	23
		Total DDT		109.7	536.3	7.5	89.0	236.1
	Drivers	pp'DDE	8	110.5	265.0	34.5	73.6	142.1
		pp'DDT		ND	56.8	ND	ND	20.1
		Total DDT		110.5	351.8	34.5	73.6	162.3
	Un-exposed	pp'DDE	7	29.0	94.8	6.0	8.0	53.5
		pp'DDT		ND	12.3	ND	ND	10.0
		Total DDT		29.0	94.8	6.0	14.5	65.8
General	Sprayers	pp'DDE	41	107.3	518.5	7.5	66.1	155.0
		pp'DDT		23.3	476.0	ND	14.0	83.0
		Total DDT		135.5	875.5	7.5	91.0	285.2
	Drivers	pp'DDE	20	102.7	374.0	34.5	77.5	179.5
		pp'DDT		24.3	204.8	ND	ND	75.0
		Total DDT		147.7	562.3	34.5	106.3	227.3
	Un-exposed	pp'DDE	13	14.7	94.8	ND	7.8	31.5
		pp'DDT		ND	23.0	ND	ND	10.7
		Total DDT		22.5	94.8	ND	12.7	41.0

ND = not detected.

( $p > 0.05$ ), but a highly significant difference ( $p = 0.001$ ) was found in p,p'DDT levels. This is due to the fact that, according to FUNASA/MT, DDT was applied more intensively in the District of Sinop in more recent years. Figure 2 presents a boxplot of total DDT serum concentrations for the two districts and three working functions on which these comparisons are best observed.

In general, total DDT levels for the exposed group in the two districts were higher than those found in the most recent study conducted on sprayers in São José do Rio Preto, São Paulo State, Brazil (Minelli & Ribeiro, 1996a). However, the results of the present study were lower than those reported by Carvalho & Berbet (1987) in sprayers from Sucam (Superintendency of Public Health Campaigns) who also

had early but not recent exposure (mean total DDT = 258.28µg/L).

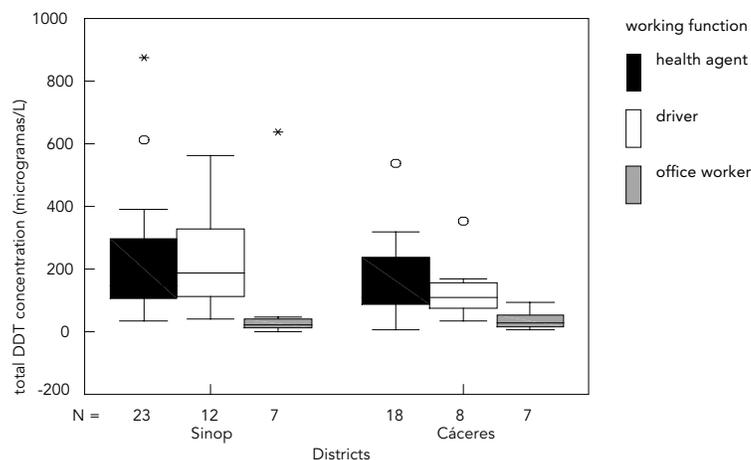
From the samples analyzed in this study, four individuals in the District of Sinop and one individual in the District of Cáceres presented total serum DDT above 500µg/L. It is important to emphasize that the occupationally exposed individuals analyzed had used DDT up to 1997, when exposure to this substance was terminated. Consequently, it is likely that more individuals had high concentrations when still exposed to this insecticide.

## Conclusions

Both sprayers and drivers were occupationally exposed to DDT as a consequence of their job

Figure 2

Boxplot of blood serum total DDT concentrations of workers of FUNASA/MT in the Districts of Sinop and Cáceres, Mato Grosso, Brazil.



activities. Total DDT levels for these two exposed groups did not differ statistically and were higher than those reported by Minelli & Ribeiro (1996b) in a recent study with sprayers, but were lower than those observed by Carvalho (1991) in another study with this same category of workers in Bahia State. Concentrations of the DDT metabolite p,p'DDE generally higher than those of p,p'DDT indicate non-recent exposure.

The occupationally exposed group, sprayers and drivers, presented DDT levels significantly higher than those of unexposed workers from the National Health Foundation (Mato Grosso State) in both districts. These high levels are probably due to the fact that exposed workers did not use personal protective equipment, as reported by Souza (1998). Median total serum DDT for the unexposed group was lower than the mean value for the unexposed population, 30µg/L, as stated in Act 6,514 (Dec. 22, 1977) of the Brazilian Ministry of Labor.

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