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Case Reports

Illicit coca grown in Mexico: An alkaloid and isotope profile unlike coca grown in South America

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ABSTRACT

Illicit coca has historically been cultivated in the Andean ridge of South America. A field of illicit coca was seized in late 2014 within the state of Chiapas, Mexico. The leaf was identified chemosystematically and the cocaine extracted from it was subjected to alkaloid and isotope analyses to determine its geospatial profile. The leaf was determined to be *Erythroxylum novogranatense* var. *truxillense* containing 0.36% cocaine. The leaf contained extraordinary levels of 1-hydroxytropacocaine (21.3%) and cinnamoylcocaines (242%), relative to cocaine. The ^{2}H incorporated within the cocaine was enriched (−178.3‰), while ^{15}N was quite depleted (−12.9‰). Incorporation of ^{18}O and ^{13}C into the cocaine were mid-range (17.4‰ and −34.3‰, respectively). The alkaloid and isotope profiles of the extracted cocaine were unlike any of the known 19 regional profiles within South America. The unique profile of Mexican coca will be a useful indicator for determining if any cocaine samples seized within the United States actually originated from coca grown in Mexico.

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1. Introduction

The coca plant has been historically and exclusively cultivated within the Andean ridge of South America for illicit purposes [1]. The four known varieties, *Erythroxylum novogranatense* var. *novogranatense* (ENVN), *Erythroxylum novogranatense* var. *truxillense* (ENVT), *Erythroxylum coca* var. *ipadu* (ECVI) and *Erythroxylum coca* var. *coca* (ECVC) are all utilized for illicit cocaine production [2–7]. Recently, 15 new cocaine-bearing cultigens of *Erythroxylum* were characterized as being used in illicit cocaine production [8]. Over the past several years, there have been unconfirmed reports of illicit coca growing in Latin America and Africa. Coca plantations within Mexico were initially verified in late 2014. Although Mexico is a major producer of heroin and marijuana that is imported into the United States, drug trafficking cartels in Mexico have until now, only served to transport cocaine flowing out of South America. Extensive propagation of illicit coca for cocaine production outside of South America could have significant implications on the current status of geosourcing cocaine and interdiction efforts within the United States.

2. Case

On September 9, 2014, the seizure of a coca plantation consisting of 1639 coca plants took place near Tuxtla Chico, Chiapas, Mexico (Fig. 1). Approximately 70 g of dried leaf material from this seizure was submitted to this laboratory for analysis. A second coca plantation of approximately 200 coca plants was seized the same day approximately 7 miles away, however, no leaf material was submitted for analysis. Herein, we report the in-depth analyses for the first known illicit coca cultivation outside of South America and within Mexico.

3. Methods

All solvents were distilled-in-glass products of Burdick and Jackson Laboratories (Muskegon, MI). *N*-Methyl-*N*-trimethylsilyltrifluoroacetamide (MSTFA) was obtained from Pierce Chemical (Rockford, IL). All other chemicals were of reagent-grade quality and products of Sigma-Aldrich Chemical (St. Louis, MO). Peruvian coca leaf, all tropane alkaloid standards, and internal standards (ISTDs) were part of the authentic reference collection of this laboratory.

Cocaine quantitation of the leaf and determination of minor alkaloids was performed as described previously [8–11]. Gas chromatography/mass spectrometry (GC/MS) was performed using an Agilent Model 5975C quadrupole mass-selective detector (MSD)

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Fig. 1. Map depicting general location of coca plantation seizure in Chiapas, Mexico and South American growing regions (Colombia = red, Peru = green, and Bolivia = blue).

interfaced with an Agilent 7890A gas chromatograph. The MSD was operated in the electron ionization mode with an ionization potential of 70 eV, a scan range of 34–700 mass units, and at 1.34 scans/s. The GC system was fitted with a 30 m × 0.25 mm ID fused-silica capillary column coated with DB-1701 (0.25 μm) (Agilent, Santa Clara, CA) in constant flow mode at 36.5 cm/s of helium. The GC oven was temperature programed as follows: Initial temperature, 170 °C; initial hold, 1.0 min; temperature program rate, 4 °C/min to 200 °C; hold, 0.0 min; temperature program rate, 6 °C/min; final temperature, 275 °C; final hold, 9.0 min. The injector was operated in the split mode (22:1) and at a temperature of 280 °C. The auxiliary transfer line to the MSD was operated at 280 °C. An approximately 2 mg/mL equivalent of cocaine in $CHCl_3$/MSTFA from the Mexican crude alkaloid matrix was injected with a volume of 2 μL, while approximately 8 mg/mL equivalent of cocaine from the Peruvian crude alkaloid matrix was injected with the same volume. Isotope ratio mass spectrometry (IRMS) of the extracted and purified cocaine was conducted as described previously [12].

4. Results and discussion

The leaves were relatively small and light green in color, measuring approximately 4–5 cm in length and less than 2 cm in width with an elliptic shape and narrowing at the base. The leaf sample did not contain any seeds. Visually, the leaves were fully characteristic with the morphological features of *Erythroxylum novogranatense* var. *truxillense*. The leaf contained 0.36% cocaine. The alkaloid profile as compared to the four known cultivars is shown in Table 1 and structures of the major alkaloids are illustrated in Fig. 2. The Mexican-grown coca has significantly elevated levels (ca. an order of magnitude) of cinnamoylcocaines (242%) and 1-hydroxycocaine (21.3%) when compared to ENVN and ENVT, while truxilline and tropacocaine concentrations (23.5% and 6.1%, respectively) are within the range of those varieties. The chemosystematic classification of the Mexican-grown coca is relatively straightforward. Only ECVC and ECVI contain trimethoxycocaine and other trimethoxy-substituted alkaloids, while ENVN and ENVT only contain 1-hydroxytropacocaine and elevated levels of tropacocaine [8]. Although the cinnamoylcocaine and 1-hydroxytropacocaine levels are elevated, the characteristics of the Mexican-grown coca fall well within the ENVN and ENVT classification. The morphological characteristics in combination with the alkaloid profiles place the Mexican-grown coca into ENVT. The GC/MS profile of the Mexican-grown ENVT is illustrated with Peruvian-grown ECVC for comparative purposes in Fig. 3.

The stable isotopes of hydrogen, oxygen, carbon, and nitrogen incorporated into the cocaine molecule are indicative of the environment in which the coca plant was grown [12,13]. Along with the three alkaloid variables used in chemosystematic classification, the isotopic values obtained from the extracted and purified